Tools for Changing the World

A Design Science Primer

Medard Gabel and David Heeney

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The most important fact about Spaceship Earth:
it didn't come with an operating manual.

— Buckminster Fuller

Dedication

This book would not be possible without the life and work of Buckminster Fuller. It is his insights, values, vision, and design initiatives that have informed and inspired the work found here.

Acknowledgements

The authors would like to acknowledge those who worked with Medard Gabel on an earlier version of this book, including Robert Blissmer, Howard Brown, Robert Cook, Geoffrey Hoare, Cathy Horvitz, Jack Ren Marquette, and Gail Ziegelmeier. That book, the *Environmental Design Science Primer*, now almost fifty years old and seriously out of date, nevertheless served as an organizational inspiration for this document. The authors of this present volume thank those whose work inspired us.

CONTENTS

PART 1

PART 2

PART 3

PART 4

FIGURES

INTRODUCTION

The following three quotes by Buckminster Fuller encapsulate the role, challenge, and method of design science— and the organization of this book.

OUR ROLE

> *"We are called to be architects of the future, not its victims."*

THE CHALLENGE

> *"How do we make the world work for 100% of humanity, in the shortest possible time, with the least amount of resources and ecological impact, through spontaneous cooperation, without the disadvantage of anyone?"*

THE METHOD

> *"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."*

Tools for Changing the World presents a methodology for changing the world— or in more detail, it provides a set of tools that when used creatively lead to the development of innovative solutions to real-world problems that can be implemented at scale to solve the critical problems facing the world.

An important part of the methodology is perspective, attitude, and the role we see ourselves playing in the world. The attitude is that we are not here to be victims of apathy, trends, chance, incompetence, misinformation, or the whims of politicians and other so-called leaders, but that we have agency. We can act to impact the future. Just as war is too important to be left to generals and politicians, making the world work for everyone is too important to be left to politicians, corporate executives, bureaucracy, or chance. Empowering this attitude and perspective is a "big picture" or whole systems perspective that sees beyond symptoms and known options.

The methodology is design science. It seeks to not just "solve problems" but to develop and build new alternatives that transform existing problem areas into visionary designs of what we want, not what we are trying to avoid.

The methodology and this book deal with the above quotes by Buckminster Fuller in four stages:

Part One— Starting Up presents frames of reference and context for our role, the challenges facing the world, and using design science to get the world what it wants.

Part Two— Tools presents a series of conceptual tools that can be used to respond to the challenges of the world we seek to address, and which shape our use of the design science method.

Part Three— Methodology deals with the heart of the design science process— the step-by-step approach of its design process. From picking and clarifying the problem situation we focus on to envisioning the preferred or ideal state of that situation, defining the problem and the present state within which the problem (and many of its possible solutions) resides, to determining creative alternatives and blending them into a regenerative, resilient, and affordable strategic design and implementation plan.

Part Four — Implementation focuses on taking our design solution to the next level, making it *real*— by getting it implemented in the real world and positively impacting the people whom the problem situation impacts.

Implementation includes documenting *what* the design solution is, *how* it works, its impacts, *who* will implement it, and *when*— over what time period, its *cost*, and where *funding* and *partners* can be obtained.

The implementation process also involves designing and developing a test case, a proof-of-concept prototype of the design solution that includes a specific site in a specific country. This functions as a key step in marshalling the support needed to bring the design solution to scale— getting it implemented so it has the impacts your ideal or preferred state envisions. Part of this process is communicating with others and forming collaborative partnerships and sponsorships. This step gains support from funders, on-site collaborators, and organizations (and government officials where needed). With positive results and the learnings we gain from the proof-of-concept, the next step is developing a strategic design and plan for scaling our solution so that it positively impacts the most people in the quickest amount of time.

The four sections of *Tools for Changing* the *World* outline the design science process from concern or outrage at the existence of a problems situation and its human and environmental costs, to a methodology for developing and implementing a design for the elimination not of just the problem, but for reaching an ideal or preferred state that transforms the world.

In summary

Design science is a methodology for creating desired futures. It is where values and vision are added to experience to change the world. It is a methodology for recognizing, defining, and solving complex problems.

Design science is a way of changing the world in preferred directions that is based on innovation, does more with less, builds resilience and thrives on transparency and collaboration. It is the comprehensive and anticipatory application of the principles of science to the creative design of solutions to the problems of society and the fulfillment of its potential.

Design science is where vision, values, critical thinking, and creative imagination combine with a global, whole systems perspective and a problem solving and strategic planning methodology that leads to informed, effective action for changing the world.

This document presents a way of using design science that helps us see and understand the problems we are concerned with and organize our thinking in such a way that our actions are effective and lead to regenerative change and transformation. The authors hope that our efforts to present the exciting possibilities of a methodology for changing our world are useful to us and our world.

PART 1

STARTING UP: FRAMES OF REFERENCE

Part 1 Provides a big picture vision of change in which design projects and initiatives can be understood and conceived.

> *Perspective is more important than IQ.*
>
> — Nicholas Negroponte

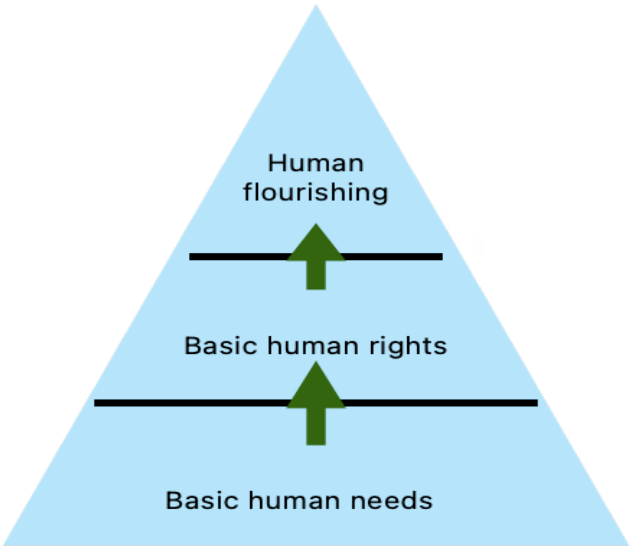
Change your perspective and you change the world.

What Do We Want?
What does the world want?

Design science begins with first principles. At its most basic level, that means three things:

- 100% of humans have their basic human needs and rights met. They flourish as they continue their development as a successful species on Earth.
- All natural systems are recognized and respected as the basis for human and all life's well-being. Life flourishes.
- Humans can intervene in human and natural systems and design outcomes in ways that benefit nature and humanity.

Human development and flourishing



Basic human rights:

Life, liberty, security of person; recognition before, and equal protection of, the law; privacy; freedom from discrimination, torture, slavery, arbitrary arrest; freedom of thought, religion, expression, movement, nationality, marriage, family, ownership of property, peaceful assembly; access to government participation, voting, public service, elections, security, work, equal pay, leisure, arts, social services and free education and health care.

Basic human needs:

Food, water, sanitation, shelter, health care, education, energy, transportation, communication, a clean and healthy environment, water, food, & all natural systems thriving.

Figure 1 The global hierarchy of human development.

For humanity to flourish, the basic needs of all humanity need to be met and the basic human rights need to be guaranteed and delivered. Over 700 million people live in extreme poverty in the world,[1] 4 billion lack access to essential health services,[2] and over 2.3 billion people live where they do not have their basic human rights fulfilled.[3]

Natural Systems Flourishing

Human flourishing is not possible without the flourishing of our environment within which we live. In a deteriorating environment it will be difficult to impossible to meet basic human needs for clean air, water, food, and safety. Human life is dependent on natural systems, including the climate, the hydrogeological cycle, and biological systems. Given this, design science works with nature to meet human *and* natural system's needs so they both thrive. Given the importance of nature to human survival and flourishing, the mandate for the *rights* of nature— to protection from harm— becomes compelling.

Global Goals for Global Flourishing

Figure 2 United Nations' Sustainable Development Goals

1 UN, Sustainable Development Goals. https://www.un.org/en/exhibits/page/sustainable-development-goals#sdg1

2 World Health Organization, https://www.who.int/news/item/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses

3 Our World in Data. Basic human rights defined as "the extent to which people are free from government torture, political killings, and forced labor; they have property rights; and enjoy the freedoms of movement, religion, expression, and association." Between 63% and 71% of all the people in the world have their human rights met (29% to 37% do not). https://ourworldindata.org/human-rights

There is a good deal of work on what it means for humans and our environment to 'flourish' as well as ways to measure it. The UN's Sustainable Development Goals are one very useful and well-thought-out definition of what is needed for achieving basic human and environmental needs.[4]

Where is the world going?

> "The best way to predict the future is to plan it."
>
> — John Platt

Earth and the natural and human systems within it are constantly changing. Some of these changes can be anticipated, some are completely unexpected. Different disciplines and approaches to planning have different ways of attempting to deal with these changes. A common view is that we just need to *predict* the future, perhaps based on historical trends. In the very near term, this may be reasonable, but as the time horizon is extended, there is increased uncertainty about what will happen. Some analysts have represented this as a cone, with uncertainty represented by terms such as 'plausible', 'probable, 'possible' and 'preposterous.[5] Although design science does not ignore these considerations, it's primary focus is on the preferable and the possible. Or said a bit differently, it focusses on making the preferable—what we want and need—possible. Design science is the art and science of transforming what we want and need into what we have. It is where vision, hope, experience, and design meet the future.

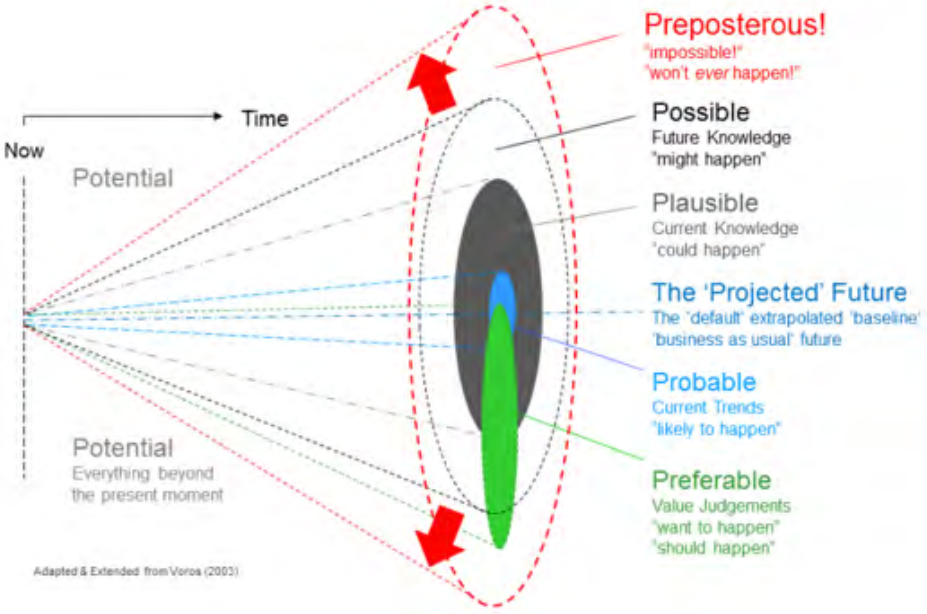


Figure 3 The Future Cone: how might the future develop?

4 United Nations Department of Economic and Social Affairs, "The 17 Goals," United Nations, 2023, https://sdgs.un.org/goals.

5 Joseph Voros, "The Futures Cone, Use and History," *The Voroscope: Exploring the Totality of Human Knowledge* (blog), 2017, https://thevoroscope.com/2017/02/24/the-futures-cone-use-and-history/.

Models of change/Changing the world

> "In times of change, learners inherit the Earth while the learned find themselves beautifully equipped to deal with a world that no longer exists."
>
> — Eric Hoffer

This book is about change.

Behind every change is a theory of change. The theory answers the questions, "What is change? How do we understand it? How does change happen? How do we bring it about?" The following five pages show how we think change happens. This book is about how we bring it about.

Everything that is shaping the world is brought about by various processes of change and their interactions. Processes, such as globalization, decentralization, democratization, technological innovation, economic development, evolution, design and planning are drivers of change.

Big picture change

Change is not a stand-alone event or singularity. It is plural. Something always changes in relation to something else. It gets bigger, smaller, closer, older, better, easier, more complex, more numerous relative to a reference point. We measure ourselves, our society, and most everything else, by how it and we change.

Change is what happens when the relationship between two or more entities shifts or transforms. Some forms of change are the result of large-scale natural and human generated processes. Some change is human generated.

Some aspects of change are seen as systematic and predictable, and others as random or coincidental. One form of the non-predictable changes are those that emerge from the accumulated interactions of parts. These emergent properties arise from the increasingly complex interactions of relatively simple parts. For example, the examination of a water molecule does not disclose a "surface" of the water. It is only when many water molecules are added together does a surface emerge.

Societal change is a highly complex process, involving many factors, such as demography, technology, availability of resources, politics, culture, needs, expectations, economics, and the interaction of these factors. Geography, access to resources, trade, and openness to outside influences can have an impact on how a society changes, develops, or disintegrates.

Living systems–social, economic, and political systems–change over time so they can maintain stability. The parts of all living systems are born, grow, reproduce, and eventually die. In this process, they change various aspects of themselves and the bigger systems of which they are a part. In turn, these larger systems change as they maintain the stability necessary for growth and evolution.

Human systems change because human beings change: they learn. Because it is difficult to impossible to learn less as we experience our lives (although many dogmas seek, at minimum, to freeze our learning at some convenient, understandable, or exploitable level), we learn more and more. And as we do so, we learn how to improve our surroundings and our lives. We learn how to do more with the resources we have access to. We learn how to improve our tools and organization so that they do more for us with the same or fewer resources. In short, we change. The purpose of which is to improve, while maintaining stability.

Our picture: Change we initiate

The change we are most interested in here is the change that we bring about by our actions. Controlled or designed change is how we systematically change the world for the better. It is this type of change that this book if focused on. How do we bring about the changes we want? Or accelerate the ones we think are going in the right direction? How do we avoid the ones we don't want? Or reverse the ones going in the wrong direction? The science of design is the systematic process of changing something in a preferred direction. Like other sciences, it formulates hypothesizes (Is it possible to provide clean abundant energy supplies in rural villages in the developing world ?), tests these hypotheses (Will this solar panel provide enough energy in an affordable manner to meet the villages needs in a sustainable way?), and maximize what we can learn from our failures (Why didn't this configuration work as desired?)

The important thing about designed change is that it can be used by anyone to improve their world.

> "Some people change the world by imposing their will on it. Some people change the world by discovering a truth. Some people change the world by changing people's minds. Some people change the world by creating things of great beauty. Some people change the world by making new tools for change."
>
> — Danny Hillis

You can change the world

You can change the world. In fact, you already have. Your mere existence has impacted the world in many ways: as a generator of carbon dioxide and other by-products of your metabolism, as a consumer in the global and local economy, as a producer of some good or service for those same economies, as a parent, child, brother, sister, husband, wife— we have all impacted our homes, communities and by extension through the interconnections of globalization, we have impacted the world. That was the easy part.

Seven techniques for changing the world

But the above, "You can change the world" has a more dramatic, and important, meaning. You can also change the world volitionally. Not just through your passive presence in the world as a biological entity or part of an economic or family unit— you can, with intelligence, persistence, hard work, courage, initiative, and the synergy of "luck" that the previous qualities lay the groundwork for, change the world. That is, you can do something so innovative, so original, or so audacious, or so obviously right, or so sensible, or so perfectly matched to the needs of the time, that the world beats a path to your door and what you have done gets implemented at a local and then global level, it gets replicated around the planet, and becomes part of the global culture.

You can change the world. There are ways that people have been doing exactly this for millennia. There are seven major techniques:

1. **Evolution:** The first and, up to now, the technique responsible for the most change, is evolution. Evolution is the slow change brought about by the long-term processes of nature selecting out the organisms and techniques and tools that lead to the most success over time of surviving.
2. **Revolution:** There are two major revolutionary pathways. One is relatively slow, lasting, and takes place in social, technological, and economic spheres. The other is faster, not necessarily long-lived, and takes place in the political arena.
   a. Non-violent, knowledge-based revolutions, and their application as technology, such as the agricultural, industrial, and information revolutions, brought about widespread and profound change in all aspects of human life and well-being.
   b. Violent political or ideological revolutions, based on ideology and the use of weapons to overthrow or change political leadership, such as the American, French, Russian and Cuban revolutions brought about rapid political change.
3. **Non-violent social action:** Mahatma Gandhi and Martin Luther King, Jr. are examples of leaders of non-violent social movements of this kind. Whether passive resistance, economic boycotts, or massive marches on political seats of power, this change mechanism has brought about huge changes in political and social realms. Another example of this form of change is the non-violent, orderly change that comes about in political structures, usually democracies, through voting and political decision-making processes.
4. **Scientific research:** Who has more impact on the world, Karl Marx or the inventor of the telephone? Richard Nixon or Albert Einstein? Our increased understandings of how nature works, the scientific breakthroughs over time, have changed the world in more profound ways, and more rapidly and universally than almost any other technique.
5. **Business and markets:** In an age when everything is interconnected, the meeting of a need through a product innovation has the potential to change the world more rapidly than almost anything else in the past. Business can spread the advances of science as well as the ethical sensibilities of enlightened self-interest

and concern and compassion for all the citizens of the world. It also has the option of ignoring these later considerations, focusing on just short-term gain, and harming environmental and social systems in which it is embedded.

6. **Personal initiative:** This, and perhaps the most important, technique incorporates elements from all the other techniques and leverages them to change the world. With the exception of evolution, none of the above happen without individual initiative. Innovation is the key to nearly all of the change agents described above. Whether it is biological initiative brought about through natural evolution, or technological innovation brought about through industrial design processes, market pressures, or curiosity, innovation is the key.
7. **Design science:** It couples the principles and findings of science with a moral vision of what should be and then takes the personal initiative to develop solutions to real-world problems that can be implemented in markets and by governments, corporations, organizations, and individuals. It is based on individual initiative and uses market economies wherever appropriate. It shares a concern for peace and social justice with those like Martin Luther King and Mahatma Gandhi but uses technological and social innovation as change agents.

Innovation is the cause of change. New technology, new decisions, new ideas, new combinations of old systems bring about change. Whether it is the agricultural, industrial, information, communication or artificial intelligence (AI) revolution, innovation was at the core of the changes. Someone found a new, and better, way of doing something that was previously being done, or they came up with a way of doing something brand new that no one was doing.

Innovation can be a variation of something already existing or a modification that improves quality or efficiency. It can be the invention of something new. It can be a borrowing from another field, or diffusion from another geographical area. Many problems can be innovated out of existence. *This is what design science is all about—innovating basic human need problems out of existence.*

Design science is . . .

"How can we use science to help solve the daunting catalogue of trans-border health, energy and quality-of-life challenges confronting our globalized, 'flattened' world? By developing scientific and technological techniques that transcend disciplinary boundaries, reflect diverse perspectives, and incorporate the contributions of traditionally underrepresented groups."

— Shirley Ann Jackson,
former President of Rensselaer Polytechnic Institute

Design science is a methodology for changing the world. It involves the application of the principles and latest findings of science to the creative design and implementation of solutions to the problems of society. And to do this in as short a time as possible. That is what this book is about.

As mentioned in the *Introduction*, there are four major parts to this book. Part *1*— *Frames of Reference*, Part 2— *Tools* Part 3— *Methodology* is a step-by-step process for doing design and strategic planning for the improvement of the world. Part 4—*Implementation* is how we make our designs real at scale so they impact the world.

Design science is a way of recognizing, defining, and solving complex problems that is based on innovation and thrives on transparency. It takes a whole system, global, and anticipatory approach that fosters creative collaboration and synergy in the development of comprehensive solutions to both global and local problems. It was inspired by the work of Buckminster Fuller and other planners, scientists, and visionaries.

Design science is . . .
"the effective application of the principles of science to the conscious design of our total environment in order to help make the Earth's finite resources meet the needs of all of humanity without disrupting the ecological processes of the planet."

— Buckminster Fuller

How is design science different from other planning processes?

Unlike many planning and political processes that compartmentalize issues and seek to develop solutions in a vacuum, design science stresses comprehensive thinking based on a clear understanding of the state of the world, available resources, appropriate technology, culture, environmental constraints, and the interconnections between world problems and opportunities. The design science planning process provides a framework for devising solutions to current problems as well as anticipating future needs.

Design science is different from other problem-solving and planning methodologies in its comprehensive, anticipatory, inclusive, and transparent approaches to the development of solutions. It takes a 'whole to particular' approach that is both global in perspective and in its examination of options. It seeks to build capacity rather than merely solve problems, and to develop solutions that are transformative rather than merely the reforming of already inadequate systems. It is informed by a moral vision that places a priority on designing ways of meeting unmet basic human needs in ways that are environmentally sustainable and socially just.

The core of this approach to problem solving and planning is both a concern with whole systems of the whole Earth, the entire history of the planet, the global economy, all of technology, and all of humanity; both those living now and those yet to be born as well as a recognition that everything is implemented locally, and that the "whole" is merely the context for the local. Design science has both a global perspective and a local focus. It is the local upon which the success or failure of a particular design solution will thrive or die.

Design science is *comprehensive,* in that it starts from the whole system and works back to the special case. It deals with all facets of a problem including the larger system of which the problem is a part; in this sense, design science seeks to build capacity, not just solve problems.

It is *anticipatory*, in that it seeks to recognize the threats coming down the pike before they arrive full blown on an unsuspecting or ill-prepared society; and it deals with the way things are going to be when the solution is going to be implemented, not just the way things are in the present.

It is a *design* strategy, in contradistinction to a political or 'let's pass-a-law-and-change-human-behavior' approach; it seeks to change the larger system of which the specific problem is a part through the introduction of innovative artifacts or policies. It is a *science* in that it seeks to use evidence-based solutions rather that politics, ideology, or wishful thinking to solve problems.

Its definitions of problems and their solutions is science based and relies more on synthesis than reductionistic thinking. (Describing design science through the paradigm of science, you can say that design science seeks to formulate its designs and problem solutions as testable hypothesis. A design prototype is an experiment to test the hypothesis. If the hypothesis, after testing is "true", the prototype can be scaled up and go into mass production.)

Table 1. Traditional Science and Design Science

	Traditional science	Design science
Method	Thesis, testable hypothesis, experiment, validation/rejection of thesis	Thesis, testable hypothesis (design prototype), experiment [building prototype], validation/rejection of thesis
Goal	Increased basic understanding of some facet of the universe	Increased understanding of a human need, and strategies and actions needed to meet that need
Objective	Seeks the most economical description of universe (the most explanation with the least verbiage)	Seeks trim tab—the solution with the greatest positive impact to a problem for least cost
Strategy	Analysis	Synthesis and taking action
Results	Once validated, they are published and become part of the scientific canon	Once validated, the results are scaled up and mass produced, and become part of the design science options canon

This *"comprehensive anticipatory design science"* is at least as much a perspective on the problems of the world as it is a methodology for tackling those problems. When applied to contemporary problems, it can lead to strikingly fresh insights and solutions.

Design science is a tool that is based on a global perspective and a systems approach to the problems of the world. It assumes that globalization has made the world an ever more interconnected whole, and any successful problem solving of society's systemic ills needs to be an approach that is global, comprehensive, visionary, and based on science, not politics, ideology, or wishful thinking. The entire world is now the relevant unit of analysis, not the city, state, or nation. At the same time, design science is also locally focused on specific conditions, climate, culture, capacities, resources, and needs. It is not a top-down approach to problem solving, nor is it a typical "bottoms up" approach. Design science combines global perspectives with a local focus that meets between the reality of specific need and global capacity. It seeks to harness the capacity and breadth of global options to the needs of a specific person, home, village, city, or region.

We are onboard, as Buckminster Fuller pointed out, "Spaceship Earth," and the illogic of 200+ nation state admirals all trying to steer the spaceship in different directions is made clear through this metaphor—as well in Fuller's more caustic assessment of nation states tending to act as "blood clots" in the world's global metabolism. And just as the Spaceship is, in fact, on one trajectory around the Sun, all the many billions of individuals aboard that ship have their unique and diverse paths and needs. Recognizing that the macro and micro are not mutually exclusive but are two sides of the same problem-solving coin, is an essential skill of design science.

The design science process is augmented by vast quantities of statistical information about the state of the world, its resources, human trends, needs, technology, and options. With the advent of personal computers and the Internet this information became almost universally available—and as it did so, design science can be undertaken by vastly more people. Coupled with the tools of the information age, design science gains the power to reach its potential. The Internet has not leveled the global playing field so much as expanded it, and the good-ol'-boy-status-quo-maintaining political process can now be subverted by a process that brings Thomas Jefferson's notions of egalitarianism into the twenty-first century.

Design science is not another specialized discipline but rather an integration of disciplines. Its practice is not a further winnowing out of the secrets of the universe, as in research at the frontiers of physics or biology, but an integrative discipline wherein the findings of the sciences and humanities are brought to bear to solve humanity's problems.

In Fuller's words, design science is a process where individuals or teams of people can "make the world work, for 100% of humanity, in the shortest possible time, through spontaneous cooperation, without ecological offense or the disadvantage of anyone."

Making the world work for 100% of humanity reflects Fuller's global perspective as well as his values. We are not here just to make ourselves rich, famous, or top consumer of the day or decade, or here

just for the 5% living in North America or Europe—or the 1 or 10% who have 85% of global wealth—we are here for all humanity. The "spontaneous cooperation" in the above quote is instructive in light of the previous discussion. The phrase does not read, "make the world work for 100% of humanity through a central government, through enforced coercion by a strong military, or the dominant superpower" but through a cooperation that arises from a fundamental transparency of society and its needs. If everyone knows what the situation is, has a clear vision of what should be and what needs to be done, we cooperate to get it done—as we do as a society in times of emergency.

Fuller said: "I am enthusiastic over humanity's extraordinary and sometimes very timely ingenuities. If you are in a shipwreck and all the boats are gone, a piano top buoyant enough to keep you afloat that comes along makes a fortuitous life preserver. But this is not to say that the best way to design a life preserver is in the form of a piano top. I think that we are clinging to a great many piano tops in accepting yesterday's fortuitous contrivings as constituting the only means for solving a given problem."

Present day problem-solving

Present day problem-solving and planning is the attempt to solve 10 to 20 year regional or global problems with 2 to 4 year local solutions staffed by bureaucrats with 1 to 2 year appointments funded with 1 year allocations that have been budgeted by politicians who can't see further ahead than 6 months, the next vacation, or next election (whichever comes first), who know next to nothing about the problem they are addressing, other than it does not, like bell bottom pants and lava lamps, seem to go away if ignored, and who were elected by voters informed by sound bites and situation comedies, and who see adversity as an excuse to go shopping. The best that we can expect from this process is that which will fail slowly. We are trying to solve vast problems with half-vast solutions. Or, as Mark Twain said, *"Sometimes I wonder whether the world is being run by smart people who are putting us on or by imbeciles who really mean it."*

Present day problem-solving and planning is usually one of two types:

- **Reactive planning:** This form of problem solving tries to undo what has been done. It seeks to prevent real change. It is orientated towards threats rather than opportunities; it repairs faults in the present rather than prepares for the future. Reactive planning usually seeks to find someone to blame; it looks for a simple thing and then removes it. Its normal mode is repression or elimination; science and technology are often seen as the villain. Reactive planning is motivated by fear. Its solutions are often human oriented. The problem solver finds out who the troublemaker is and gets rid of him. This form of planning sees the world as a series of machines.
- **Inactive planning:** This form of problem solving sees the current situation as OK and if nothing is done, things will stay the same. Their motto is "Do nothing and nothing will change." Inactive planning seeks equilibrium, to keep things the way they are.

This form of planning is characterized by people who are busy as hell doing nothing. There is an abundance of red tape, bureaucracy, committees, and elaborate rituals that give the impression of something being done. There is a paralysis of analysis, and a hesitancy that borders on inability, to act.

Present day problem solving and planning is most often characterized by the mental diseases of: *Overspecialization, reductionism,* and *local focus hocus pocus.* Attempting to solve complex, interlinked global and local problems with simple solutions is like rearranging the chairs on the deck of the Titanic. Additional dis-eases show up as:

- Scarcity/zero-sum dementia: Attempting to solve complex, interlinked global and local problems while assuming there isn't enough to go around guarantees that there will not be enough to go around.
- Crisis-to-crisis/manic/depressive management, reactive problem solving: Attempting to solve complex, interlinked global and local problems while the ship is smashing into an iceberg is neither productive nor healthy.
- Growth obsession: the fallacy of more ("Obesiodity"): Attempting to solve complex, interlinked global and local problems with more of the same is like increasing the speed of the Titanic as the solution to the iceberg.
- Mechanistic thinking: Attempting to deal with living systems with mechanical models guarantees solutions that are dead in the water.
- Dictator complex: Attempting to solve complex, interlinked global and local problems without the input, cooperation, and creative involvement of those who will benefit from the solution produces dull exercises in futility (or exciting, but deadly, voyages on "unsinkable" ships).
- Ideology as a substitute for thought: Attempting to solve complex, interlinked global and local problems with ideology is like believing your ship is unsinkable.

As the litany of problems the world faces transform from one crisis after another we are faced with an increasingly daunting challenge. Many would say these challenges are insurmountable and frightening. Others are convinced that human ingenuity is up to the task of saving itself. As H.G. Wells summarized more than 100 years ago, *"Human history becomes more and more a race between education and catastrophe."*[6]

Whether it is climate change, hunger, terrorism, lack of health care, illiteracy, water shortages, environmental destruction, economic collapse, resource shortages, natural disasters, or poverty, the race is on. Can we make the world work for everyone, in a sustainable manner, before we run out of resources, destroy the environment's ability to regenerate itself, or the have-nots get fed up with the increasing gap between their children's prospects and those of the super-rich and take matters into their own hands—or the haves, afraid of losing what they have, do the same? In a well-armed and ever-increasingly better-informed world, where everyone knows how the other half lives, can the world afford to lose this race?

6 H.G. Wells, *The Outline of History: Being a Plain History of Life and Mankind* (New York: The Macmillan Company, 1920), https://www.gutenberg.org/files/45368/45368-h/45368-h.htm#Volume_II.

Will we be able to figure out how to meet the basic human needs of 100% of humanity in time? The technology and resources are available to feed, clothe, house, provide clean water, sanitation, energy, education, health care, communication, and transportation so that all of humanity has, at minimum, their basic human needs met. Given this, the challenge before us is fundamentally a design challenge: how do we design and redesign the world's life-support systems so that everyone is taken care of? How do we do this in a sustainable, circular, and regenerative way? And, how do we do this in the shortest time possible? That is what this book is all about.

Table 2. Present planning compared to design science

Aspects	Present planning	Design Science
Area of focus	Local	Global and local in global context
Time horizon	Short range	Long range
Response	Emergency/crisis to crisis/reactive	Anticipatory/ proactive/ initiative
Models	Mechanistic	Biological
Methodology	Reductionism/ specialized	Synthesis/ Comprehensive
Resources	Assumes scarcity	Assumes enough for all/abundance
Approach	"Solves" problems; reactive or inactive	Builds capacity; proactive
Environment	Non-sustainable	Regenerative
Solutions	Laws that seek to change people	Artifacts that change the environment
Political framework	Top down	Network
Social role	Status quo	Change makers
Business approach	Manager	Visionary Entrepreneur
Problem approach	Reformation	Transformation

Design Science is Proactive

In contrast to reactive and inactive planning, design science assumes the future is controllable. Life depends less on what happens than what we do. Design science is concerned with developing a vision of a desirable future and the ways of bringing it about. It is concerned more with designing the future than forecasting it, and the idealization of a system rather than its optimization. Design science is motivated by aspiration rather than fear.[7] Design science is a method for developing the life preserving and enhancing solutions to society's problems. It is a method of doing away with the fortuitous contrivings of society and replacing them with designed solutions that are regenerative, affordable, and increase the well-being of the whole world.

> "Most current efforts to improve society are directed at getting rid of what we do not want rather than getting what we do want. Getting rid of what we do not want often results in getting something worse."
>
> — Russell Ackoff

Just as local Band-Aids on systemic problems do not help anyone but bandage manufacturers, local, small-scale efforts aimed at systemic problems are addressing vast problems with half-vast solutions.

7 The descriptions of present planning methods and design science are derived from Ackoff, Russell, *Redesigning the Future* (New York: Wiley, 1974). and Russell Ackoff, Jason Magidson, and Herbert Addison, *Idealized Design: Creating an Organization's Future* (Upper Saddle River, New Jersey: Prentice Hall, 2006).

Some people change the world by making new tools for change. As a dramatic example of changing the world by making new tools, I include the creation of the Internet. I would also list something like building the rural credit system in Bangladesh as another example. Changing the world in this way can involve changing people's minds, and can entail imposing one's will to some extent, but it is mostly about enabling other people to change—by giving them tools to do so. This feels like progress. The other appeal of tool creating is that change brought about this way is self-sustaining and self-correcting. By self-sustaining, I mean you can use tools to make other new tools. This gives enabling tools a self-amplifying effect that can gain importance with time. I like that. I feel this is a very different way to change the world from trying to impose your will on it, because when you do that the world tends to snap back after you stop trying, or after you leave. Also, enabling change through tools is self-correcting. People who try to change the world by imposing their will on it often cause unintended harm, because the consequences of the change are hard to predict. When the beneficiaries control the change themselves, they have a lot more opportunity for feedback. Thus, change of this sort has a better chance of being good.

—Danny Hillis
Whole Earth Winter 2000

PART 2

TOOLS: BEST PRACTICES/CONCEPTUAL TOOLS/PERSPECTIVES

Part 2 Provides tools for thinking, organizing, making sense, and developing solutions to complex systems and problems.

" Humanity on Earth teeters on the threshold of revolution. It has to be success for all or none. If the revolution is a bloody one, humanity is through. The alternative is a design-science revolution." .

— Buckminster Fuller

A conceptual tool is a concept used for patterning thoughts; it is often a metaphor that organizes information. For example, the metaphor "Spaceship Earth" organizes our perceptions about our environment in an entirely different way than just the word "Earth." The conceptual tool is a method for organizing information, thought and eventually behavior.

The following conceptual tools have been found to be effective for organizing, explaining, and predicting various facets of our information environment in ways that lead to effective solutions to global and local problems. The design scientist uses these tools to elucidate relationships among existing information and to help produce new information. These conceptual tools should be viewed as a set of interrelated concepts to be used as a whole.

Big picture design

Everything is design.

Whether it is the highway sign or the highway itself, the car you drive, the coffee cup you drink from, or your home, this book, the music you listen to, the movies you watch, or the language you use, *everything* including you and the Universe itself is design. Everything you can see, hear, touch, smell, or taste is a design, and has, in some form or another, "design

specs". Everything you can apprehend or understand is because of the design of what something is.

The design could be in the blueprints, technical drawings, artist's vision, DNA, or the generalized principles of the cosmos, but design plays a crucial role; without design, nothing is.

Design is conceptual, weightless. It is information, organized by intelligence. Information, as design, determines what matter and energy can do. As such, it controls matter and energy. And because information, as know-how (and know-what, and know-where, and why) is essentially unlimited unlike our material and energy resources, it is the conceptual underpinning of the profoundly important claim and imperative that there is enough to go around on our limited planet to take care of everyone. Without the dramatically increased amount of know-how, compared with the stone age, for example, there is no way we could meet the basic human needs of the world's current population, nor those who will be added in the coming decades.

Why does this matter? As we will see, good design progressively substitutes information for matter and energy and does "more with less" more strength, functionality, for longer periods of time, while using less materials and energy. As, for example, a high-strength metal alloy does more with less than its same weight non-alloy counterpart and allows us to build extraordinary things like jet engines, long bridges, and super sharp scalpels; or the latest microchip that does more computations per second while using less energy than its predecessor, allowing ever more useful computers, mobile phones, and hybrid or electric vehicles.

> *"Design is intelligence made visible."*
>
> — Louis Danziger

Whole to particular

Design is critical to the survival and well-being of the billions of people in the world. By one accounting, eighty percent of environmental impacts are determined at the design stage.[8] Given the above discussion, a case can be made that all environmental impacts are the result of design decisions.

All the products, services, and infrastructure that are meeting the needs of the world's population are the result of design. Some of this design is good, some shortsighted; a lot of it is unconscious, and even more the result of haphazard muddling through.

Whatever the problem or need, design plays an essential role in making the world work. Whatever the vision of how things should be, design plays an even more important role which brings us to the reason for this book: If we are better at design, we will be better at meeting the needs of all the people of the world and we will be better at making real our vision of how things should be.

8 Design Council, *Annual review 2022*. London, Design Council, p.19.

Thinking in systems

Thinking in systems helps us recognize, define, and solve problems. Everything we can describe is a system because anything we can identify is, by nature, composed of a plurality of components. Earth is a system, you are a system, and I am a system. What we design is a system. So, what are systems? Here are their characteristics:

- A system is a whole. It has parts that interact and a boundary that divides it from the outside world.
- It is a set of two or more interrelated elements that can be subdivided into parts.
- Every system's behavior is a product of synergy. The parts of a system interact in ways such that the behavior of the whole system is unpredictable if you look at just the behavior of the parts. The corollary of the law of synergy is that the known behavior of the whole and some of its parts makes discovery of the remaining parts possible.
- A system's boundary divides the world into everything that is inside the system and everything that is outside the system. Changes often occur at the boundaries— where a system comes in contact with other systems of which it is a part, and its environment.
- A system is a stable organization of interacting parts. Systems change to maintain dynamic equilibrium.
- Systems are goal-seeking, having their own agenda based on the interaction of their parts. This agenda is seldom, if ever, completely understood, especially by the parts of the system.
- Systems have delays and time lags between an action, reaction, and resultant.
- You cannot change just one thing in a system. As a stable pattern of interacting parts, everything in a system is interconnected.
- Systems modify their environments, which in turn, modify the system (this can sometimes be seen as "every solution creates new problems").
- The more a system can change (the more adaptable, resilient) the better it is able to survive and thrive.
- Some systems change cyclically. Some change is transformative. Transformative change is change to new levels. This is often called "phase change."
- If a system is not allowed to change non-violently, it will change violently. (Wars can be seen as a systems response to inflexibility or inability to change in non-violent ways.)
- Systems have feedback, both positive and negative.
- Systems self-organize.
- Living systems are self-maintaining, repairing and replicating.
- All living systems are made of matter and energy organized by information. The human body is a complex system comprised of less complex systems (nervous, circulatory, digestive, muscle/skeletal, etc. systems), organs (heart, stomach, etc.), cells, molecules, and atoms.
- All systems, whether ecological, technological, social, or conceptual have an environment into which they fit. Systems are organized hierarchically.

- Systems follow general rules or "laws" that help in explaining present behaviors and predicting future ones.

Being able to clearly understand relationships between a system and its environment is crucial because systems are always affected by their environment. (There are a number of tools that help us clarify a system's interactions with its environment. These are discussed in Part Three.)

Why think in systems?

Thinking in systems means that the designer/problem solver/strategic planner sees the world as interacting units that follow certain general patterns of interaction.

Systems thinking helps the problem solver see the world at a level of detail that is not so complex that any action is hopelessly mired in such minute detail that cause and effect is undetectable, nor so simplistic that any suggested action is unrelated to a measurable impact. Systems help the problem solver recognize cause and effect, action and impact, and general patterns of development. But this only works if the analysis is on a consistent *level of aggregation*.[9] It does not work if the systems being related are on, for example, the molecular level and that of social systems.

Some useful general rules or patterns of systems include:

The law of whole systems /synergy

"Synergy" (the behavior of the whole is unpredictable by the behavior of the parts taken separately; or more simplistically—the whole is greater than the sum of its parts), is embodied in the very definition of a system. It's corollary, "the known behaviors of the whole system and the known behaviors of some of its parts makes it possible to discover or to predict the behavior of the remainder of the system's parts" can be a useful tool in design science. For example, knowing the behavior of what the preferred energy (or other system) is helps the designer decipher the behaviors of the parts of that system. (For more on this, see "Preferred State Envisioning" in the *Methodology* section.)

Another facet of the principle of synergy is the property of *emergence* in complex systems. When systems (materials, people, artifacts, etc.) interact there arise new properties that result from the relation of one system to another. This emergence of new properties from the relationships of the parts and their interactions with their environment underlies much of design science and the scaling of solutions to meet global problems.

9 All systems are part of a hierarchy of systems; it is essential to design science to maintain the same level of aggregation in analysis, synthesis and design of solutions. This means, for example, that if we are looking at global energy systems, that we don't analyze the world's oil reserves, hydro capacity, wind potential, and the fuel efficiency of a single car. In this case, the level of aggregation is the world, and a single car and world are an obvious mismatch.

The law of requisite variety

The law of requisite variety is a general rule formulated in the field of cybernetics. It states that the larger the variety of actions available to a system, the larger the variety or diversity of responses required to control it.[10] And therefore, the more resilient, adaptable, and sustainable the system, the better the design.

Redundancy ensures survival

Redundancy involves inclusion of additional elements not essential to the normal functioning of the system, but which protect the system in the event of the development of adverse conditions. Redundancy may mean duplication of elements of the system, or it may mean other systems that perform a similar function. For example, in a computer system, backups of data may be thought of as redundancy, as the data are duplicated, even though that duplication may be on an external storage device which is not the same as the original computer storing the data, or it may be a second computer present in case the first one fails. On the biological side, a tree may put out many seeds in the expectation that only some of them will germinate. A system that is tightly optimized for an initial set of conditions might be more efficient while those conditions prevail but fail totally should conditions change. And in today's world, conditions change constantly. For the design scientist this means that the more flexible the design, the more staying power it has.

> "If a problem can't be solved as it is, enlarge it."
>
> — Dwight Eisenhower

Starting with the whole

> *"When architects design a house, they begin with a sketch of the whole, not of each room."*
>
> — Russell Ackoff

It can also be said that before the architect begins to sketch, they have both an understanding of what the needs of the client are, and a vision of what would meet or surpass those needs.

10 Other explanations, implications and design suggestions of this rule say that those components of a system that have the greatest flexibility and freedom are the most powerful. More technically, it says that the greater the variety within a system, the greater its ability to reduce variety in its environment through regulation; in active regulation only variety can destroy variety. The variety of perturbations a system can potentially be confronted with is nearly unlimited, so trying to maximize the internal variety (or diversity) of a design, so as to be optimally *prepared* for any foreseeable or unforeseeable contingency is a good idea. Yet another spin-off of this rule is that a system can only model or control something to the extent that it has sufficient internal variety to represent it.

In order to maximize the odds of success, any problem-solving endeavor should start with the "whole" and work towards the particular. In this way, there is an increased probability of not leaving out critical variables. (Given the above dictum, *"The only way to understand a system is to understand the system of which it is a part"* by including the larger system, your analysis of the problem will not leave out important parts— plus it will reveal options not contained in just the problem.) Dealing with the whole system reveals parts, connections, and their interactions— which can often be altered in ways that lead to solutions.

There are many conceptual "wholes" from which to begin subdividing. For example, the universe, Earth, all of humanity, all of humanity's problems, all the interlinked systems of life support, all the variables of a particular problem, all of the resources of Earth, the entire history of the problem or systems being studied, *and* importantly, the preferred functioning of the system being designed. In general, the larger the system with which we start problem definition and the inventory of alternatives for getting to the preferred state, the more complete will be our work. Practically, problem analysis should begin at least two levels above the assumed level of the problem system. One of the rationales of this "starting with the whole" is that by doing so the designer has a higher probability of dealing actual causes, rather than just symptoms of problems.

As indicated above, the "Law of Whole Systems" suggests that by putting together what is known about the whole with what is known about some of its parts, it is possible to progressively understand more about unknown parts. Since "problems" are parts of larger systems, we can often solve a single problem only by understanding its relationship to other problems and to the larger environment.

Local problems should be viewed in the context of global problems for at least three reasons: first so that seemingly unpredictable aspects of the local systems can be better understood by the behavior of the larger system of which they are a part; second, so that more options that are contained in the larger systems are available to the problem solver; and third, so that implemented local solutions don't create problems elsewhere in the larger system.

Spaceship Earth

Earth is a small automated, spherical spaceship orbiting at 67,000 miles per hour (110,000 km/h) around the Sun, which in turn is on its own course at 536,000 miles per hour (864,000 km/h) within the galactic nebula.[11] With the exceptions of radiation from the Sun, slight amounts of "star dust" that fall into the Earth's atmosphere, and the gravitational effects of the Moon on oceans and atmosphere, Earth can be viewed as a relatively closed system.[12]

11 *Earth's Speed* http://curious.astro.cornell.edu/about-us/41-our-solar-system/the-earth/orbit/91-at-what-speed-does-the-earth-move-around-the-sun-beginner; Sun's speed: https://www.universetoday.com/133414/distance-speed-suns-orbit-around-galactic-centre-measured/

12 Small quantities of materials fall from outer space each day. Approximately 5 200 tons (4,700 tonnes) of dust reaches Earth's surface each year. J. Rojas et al., "The Micrometeorite Flux at Dome C (Antarctica), Monitoring the Accretion of Extraterrestrial Dust on Earth," *Earth and Planetary*

THE WHOLE WORLD IS NOW THE ONLY RELEVANT UNIT OF PROBLEM SOLVING

Globalization has, whether we like it or not, made us all one— at least in some important contexts. We have always been voyaging on one ship, the *SS Earth*, but globalization has transformed this philosophy into an economic, technological, political, and ecological reality that is unavoidable, no matter how high the walls on our gated community or how far removed from the centers of civilization we choose, or are forced, to live.

A global approach is not altruism, some noble gesture by the rich to help out the less fortunate; it is a self-serving, pragmatic economic strategy. It is not much of a leap to see the enormous implications of adding an additional three to four billion consumers to the global economy. In a regenerative system, when these new "middle class" people leave poverty behind and join the global economy, they don't deplete the world's capacity, they add to it.

Moreover, the most cost-effective solutions are now global ones. For example, it makes no sense to try to eliminate deadly or debilitating diseases from just the U.S. or Europe if we do not also eliminate them from the rest of the world. The economics (to say nothing of the ethics) are compelling: for example, since smallpox has been eradicated from North America and Western Europe, those regions have saved over $5 billion on what they were spending each year on smallpox control within their borders (vaccination, border monitoring, etc.)

In addition, more than 70 million cases of smallpox in the world have been avoided since its eradication.[13] If each of these cases caused a mere $1,000 USD in economic loss, that translates into a savings of $70 billion USD to the global economy— more than 230 times the original investment of $300 million USD that was needed to eradicate smallpox.[14] A global approach can produce cost-effective solutions to all our basic problems of human need, environmental threats, and security not just disease eradication.

Not thinking globally leads to inequalities. These in turn have been associated with concentrating and increasing poverty, decreased longevity, poor health, increased vulnerability to climate change and economic downturns, and local, national, and global

Science Letters 560 (April 15, 2021): 116794, https://doi.org/10.1016/j.epsl.2021.116794. The mass of meteorites has been estimated at 18.3 tons (16.6 tonnes) per year. G.W. Evatt et al., "The Spatial Flux of Earth's Meteorite Falls Found via Antarctic Data," *Geology* 48, no. 7 (April 29, 2020): 683–87, https://doi.org/10.1130/G46733.1.

13 40 million cases of smallpox were avoided from eradication in 1977 to 2003. Since then, an additional 31.5 million have been avoided, for a total of 71.5 million. 71.5 million X $1,000 = $71.5 billion. Sophie Ochmann and Hannah Ritchie, "Smallpox Is the Only Human Disease to Be Eradicated - Here's How the World Achieved It," Our World in Data, 2018, https://ourworldindata.org/smallpox-is-the-only-human-disease-to-be-eradicated-heres-how-the-world-achieved-it.; Richard Preston, "The Demon in the Freezer: How Smallpox, a Disease Officially Eradicated Twenty Years Ago, Became the Biggest Bioterrorist Threat We Now Face.," *The New Yorker*, July 12, 1999, https://www.newyorker.com/magazine/1999/07/12/smallpox-vaccination-the-demon-in-the-freezer.; Anonymous, "Opinion: Death Throes of a Crippler," *The New York Times*, May 27, 2003.

14 World Health Organization, "Removing Obstacles to Healthy Development" (Geneva: World Health Organization, 1999), https://apps.who.int/iris/handle/10665/65847.

political unrest.[15] On a fundamental level, as the desperately poor get their needs met, the entire world becomes more secure, stable and safe for everyone. Wealth is a function not only of how much you have, but also of where you have it. If you have $10 billion USD of gold bullion on a sinking luxury liner, you are just going to sink faster. Making the world work for one hundred percent of humanity means that wherever we are and no matter how rich we are today, we will then be even "richer" more secure, safe, and in an almost infinitely more fertile and stimulating cultural environment.

Thinking Long Term

> "If you cannot draw on 3,000 years of history, you are living hand-to-mouth."
>
> — Goethe

Design science operates in a long-term framework not next quarter's profit margin, next year's election, nor even the next generation. It seeks to develop solutions in ways that a problem transforms into additional capacity. Not only is the next generation taken care of, so are all succeeding generations. The real long-term is described in Figure 4.[16]

A short temporal focus is analogous to a small spatial focus: both are ineffectual, costly, counter-productive, and more than likely destructive to the well-being of the whole system. Whether that system is your body and the short-term focus of your fondness for fatty foods and the couch near the TV, or society's fixation on political platitudes that provide an illusion of everything-will-be-fine (if we just go backwards in time to a nostalgic place that never existed).

The short term is often at odds with the well-being of the whole over the long term. Investments in renewable energy, affordable health care, and universal education are positive examples of how a view to the long term can help in the short term. This is not to say that a concern with next quarter's profit is foolish, only that next quarter needs to be in tune with the next ten to twenty years, or longer. The larger the temporal frame of reference, the more possibilities there are and the deeper is our understanding of the past and its implications for the future.

> "A politician is a man who thinks of the next election, while the statesman thinks of the next generation."
>
> — James Freeman Clarke

. . . and the design scientist thinks for the sustainable long-term— the ages.

15 Weihua An, "Fear Not Scarcity but Inequality, Not Poverty but Instability," *Sociological Methods & Research* 50, no. 3 (August 1, 2021): 939–43, https://doi.org/10.1177/00491241211024295.

16 Medard Gabel, "Bigtime," BigPictureSmallWorld, 2005, https://bigpicturesmallworld.com/funstuff/bigtime.shtml.

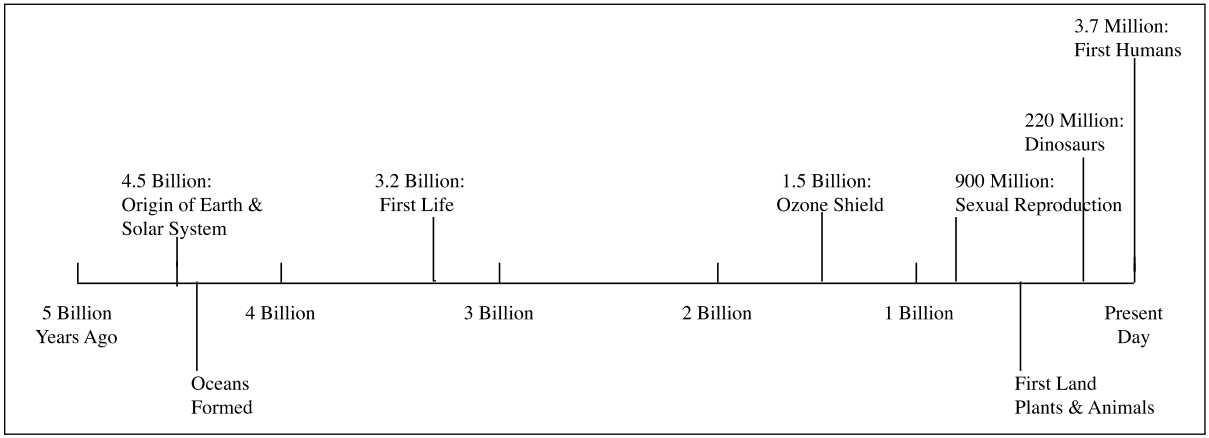


Figure 4. A global timeline from the big bang to the present day: 5 billion years.[17]

In addition, looking at the world through the long-term lens makes prevention, rather than treatment or cure, the logical and most economical option. For example, a focus on the short term led the U.S. to provide a negligible $4 million a year in aid to boost agricultural productivity in Ethiopia. In 2003 when crops failed and famine threatened, the U.S. was compelled to send in $500 million in emergency food aid.[18] Another example of a short range, "least-cost" strategy that backfired was the U.S. approach to dealing with AIDS in Africa. The U.S provided less than $50 million a year to Africa for AIDS prevention in the 1990s. By 2004, with over 20 million dead and another 30 million infected, the U.S. was spending $3 billion per year to treat the disease.[19]

A long-term focus is helpful from another perspective as well. When viewed from the long term, most everything can be seen to be part of a process that has a ***gestation rate***. For example, human babies have a gestation rate of 9 months, and elephants have a gestation rate of 21 months. The iPhone was initially conceived of in 2000,[20] and came to market in 2017. The first fax machine was invented in 1843, but only became popular with consumers in the 1980s.[21] Design science solutions to problems need to be aware of these varying rates of gestation. It also helps to realize that no matter how much you might like the

17 Medard Gabel, BigPictureSmallWorld, https://bigpicturesmallworld.com/funstuff/bigtime.shtml

18 Jeffrey Sachs, "Special Report: Doing the Sums on Africa - Developing Africa's Economy," *The Economist*, 2004, May 22 edition, https://www.jeffsachs.org/newspaper-articles/g2a4pdawbb2rhlh2r3jmcz2lc89ahc. p.19.

19 Ibid.

20 National Institute for Research in Digital Science and Technology, "Jean-Marie Hullot, from Perforated Cards to the iPhone," *Inria* (blog), 2020, https://www.inria.fr/en/jean-marie-hullot-perforated-cards-iphone.

21 Mary Bellis, "History of the Fax Machine," *ThoughtCo.* (blog), March 20, 2019, https://www.thoughtco.com/history-of-the-fax-machine-1991379.

world to change overnight, there are some processes that cannot be rushed without the risk of a still birth.

Another conceptual spin-off of a long-term focus is that *everyone is needed.* The bigger the picture the designer has, the more important becomes the input and buy-in of all the stakeholders in a given design solution. The old way caricatured above as "current planning techniques" dictated that to build a bridge you needed an engineer. Building a bridge today, we need the engineer but also the people who are going to use that bridge; those who are going to build it, manufacture the parts, and obtain the raw materials; the ecologists who will tell you where it can be placed so that it does the least damage to the environment; and most important, the citizens who will decide if they want the bridge in the first place and who will pay for it, in one way or another.

> "We are made wise not by the recollection of the past, but by our responsibility to the future."
>
> — G. B. Shaw

This is not neo-liberal do-gooder public policy rhetoric; it is pragmatic, cost-effective essentials for regenerative development. The day of "the" expert as the sole or primary decision maker is over. Or more precisely, the day of the technological expert riding roughshod over culture, ecology, and values is over. Everyone is an expert on what they want and know. Further, the expert's education and experience is a double-edged sword. On the one hand it helps them to see opportunities to apply solutions that worked in other contexts. On the other, it may blind them to novel solutions.

The discussion table needs to include all stakeholders, or the capacity building that is critical to any endeavor will not reach its potential. The nation state is no longer the only major player on the global stage. Global corporations, NGOs, and private citizens all need to work together on getting what the world wants.

If the 'problem' being addressed is to be solved (and stay solved), decision-making at the local level and input from all sectors of local society are needed. This provides learning and development opportunities for the larger system of which the problem is a part. Every development strategy is an opportunity to increase the knowledge and capacity of the society in which development is occurring.

Increasing Wealth

> "Eliminating poverty will not happen by solving problems. It will happen by creating wealth."
>
> — George Lodge

Wealth is the capacity of a society to deal with present and future contingencies. It is not money, but what we do with our information, energy, and materials. One measure of wealth is the degree to which we have rearranged our environment so that it is able to support as many lives, for as long as

possible, with increasing degrees of freedom, in as many conditions, at a high standard of living.

Wealth is not measured by money, and well-being is not measured by gross national product. Wealth is knowing what to do with energy; it is know-how plus energy and materials applied to meet human needs.

Existing political and economic systems often assume the basis of wealth is the accumulation of physical resources or the ability to wield power. This assumption ignores the concept and implications of doing more with less and leads to the mistaken conclusion that there are not enough resources to go around and so some of us are doomed to lives of brutal poverty, or worse. This false assumption of scarcity also provides a logic for war and the pre-emptive arming of your side to be prepared for an eventual Armageddon type showdown with the other side to fight over the distribution of the last pieces of the last resource pies. Assuming survival belonged to the "fittest," many political systems and their leaders see competition for scarce resources as a rationale for war.

Design science is not concerned with different ways of distributing "not enough." It is concerned with developing new ways of providing enough by doing more with less. This approach brings a new perspective to the debate between economists who advocate continued economic growth and environmentalists who recognize the limits of the biosphere and who advocate stopping growth. Neither alternative is acceptable because each means that there will always be "haves" and "have-nots" in the world or that Earth might not be able to support life in the future the consequences of which is that we will all be "have-nots."

Design science recognizes that real wealth is generated not by the quantity of resources that can be accumulated, but by the quality of their use. The more intelligently we employ resources, the more wealth they yield. The only thing we have identified in Universe that has no apparent limits to its growth is our knowledge. The design scientist demonstrates that wealth can continuously increase even though the total quantity of physical resources in use may not. This can occur if we continuously find ways of better and better reinvestment of our know-how to get more with less.

Technology as a living system/ Modeling technologies on living systems

Biology replaces mechanics

The models we use shape the way we see the world and our reality. Using mechanistic models for problems has led the world to mechanistic solutions that fail when one of the cogs in the machine fails, that are seen as " independent" of their environment, and that regularly create as many new problems as old ones they solve. Viewing the world as a living system fosters a respect for a problem's complexity,

its interconnections with other systems, an awareness of the context or environment in which it is embedded, and the possible solutions that can result in strengthening the health of the system and the elimination of the problem.

It helps us to see opportunities to apply solutions that worked in other contexts.

Viewing our technology as a collection of independent machines, each composed of myriad parts, none of which are related, all of which somehow add up to a life-support system for humanity is, in the end, a debilitating and lifeless view of technology and our role in creating that technology. Seeing our technological systems as living systems, interrelated and interdependent as the various systems and components of our own bodies and their environment, even going so far as to see technology as biology, leads to a whole new perspective on everything from the historical developments (embryology) of technology, possible options that mimic nature and living systems (biomimicry[22]), to current and future trends (teleology), and even for the philosophically minded, humanity's role in the universe (cosmology). Seeing our collective life-support system as an *external metabolic system*, analogous to, but more differentiated than, our individual life support system we refer to as our internal metabolic system, helps us realize the interrelatedness of all our technology, its multiple functions in society, and its vital role in maintaining our viability as a species. Most importantly, given the present state of our ignorance about our environmental interactions, it helps us to see the vital connections between our living systems and our environment. Viewing our technology as an external metabolic system, the healthy functioning of which is essential for humanity's health and well-being, makes the notion of "zero emissions" not just a utopian fantasy or environmental platitude but as important as stopping the bleeding of a wound to an individual human being.

Using biological models leads to the use of biological or ecosystem-based management tools. Such big picture management helps put the value of our environmental resources in a context that illustrate their true value. It leads to the reversal of management priorities—putting the value of the environment first and the target of exploitation (fish, food, forest, minerals), second.[23] In information short or uncertain circumstances it provides a logic for erring on the side of caution when setting production quotas or targets. It also helps shift the burden of proof so that economic production does not take place unless it can be shown that it does not harm or lower the value of the environment.

As we create tools, we recreate ourselves

We can view technology as an externalization of the functions performed by the human body. As our early cousins needed something sharper than fingernails, they developed the sharp stick, rock, and

22 Janine Benyus, *Biomimcry: Innovation Inspired by Nature* (New York, NY: Harper Perennial, 2002).

23 E. K. Pikitch et al., "Ecosystem-Based Fishery Management," *Science* 305, no. 5682 (July 16, 2004): 346–47, https://doi.org/10.1126/science.1098222.

eventually metal knife. As they needed something harder than a fist, they developed the wooden club, the rock hammer, and eventually the metal hammer. The clay cup developed from their needs to hold water and eventually other liquids hot, cold, acidic, boiling, melted, cooking and in quantities our cupped hands could not handle.

Seen this way, all technology owes its origins to original functions performed for primitive society by our bodies. Tools and technology become extensions of what our bodies originally did. Once externalized, the former "simple" function of our bodies took on a number of extra-ordinary characteristics. For one, it could be "mass produced" so that hundreds of others could use my hands for holding water. Two, once externalized, the function my cupped hands performed could be enlarged so that large quantities of liquids, or solids, could be contained. The externalized "hands" could also now be safely put in the fire or hold things for long periods of time without leaking. We could even make this container or vessel so large that it would not only no longer be recognizable as the externalization of the function my cupped hands performed, but so large that I could get into this vessel and take it to the other side of the lake. Most importantly, when technology is seen from this perspective, it is no longer random chaos, or merely the stuff that pollutes the world and puts people out of work. Seen as a living system that follows the general rules of all living systems, technology becomes more understandable, predictable, and "friendly". Viewing technology as a living system provides insight into the

Table 3. External metabolics extend the capacity of internal metabolics

Function	Internal metabolics	External metabolics
Distribution of utilizable resources to specific receptors	Circulatory system	Transportation system
Distribution of utilizable resources to specific receptors, integrate, regulate whole system functioning	Central Nervous system, Endocrine system	People, Government, Media, Communications systems
Organize utilizable matter/ energy configurations into forms for action on the environment	Stem cells, fibrocytes	Motors, Tool-Making Industry, Manufacturing Industries
Convert matter/energy configurations to utilizable forms or dispose of them	Digestive, Excretory systems	Smelting and Refining, Materials Conversion Industry, Waste Disposal/ Recycling Industries
Convert matter/ energy configurations into utilizable energy sources	Respiratory system	Power conversion technology
Protection from outside/ environmental forces	Skin	Shelter

interdependence of all the components and processes of our technological systems.

Just as internal metabolics is the life-support system of our bodies and individual consciousness, external metabolics is the life–support system of collective humanity. And, designing with nature is fundamental to design science because it is the best way we can assure our long-term sustainable health and well-being.

Doing more with less

"More with less" refers to the systematic process of substituting information for materials and energy. Weightless information, in the form of increased understanding and knowledge, is substituted for weighable materials and energy in such ways that the efficiency of the system is increased. "Efficiency" being defined as increased performance per each gram of materials and joule of energy used.

Getting ever-higher performance out of every gram of material and joule of energy invested in every function performed by our human-made life-support is critical to making the world's limited resources meet the needs of our growing population and to reducing our impact on our environment. The concept of doing "more with less" also furnishes the design scientist with a standard by which strategies and solutions may be evaluated. Another way of looking at this is that it is not "more with less", it is really "more with better." (and less physical materials per function performed).

Buckminster Fuller pointed out that the sum total of the world's technology was operating at around 4 percent efficiency in the 1960s.[24] An analysis of the material efficiency of the U.S. economy was estimated at around 6 percent.[25] By raising the efficiency of how we manufacture, use, and dispose of our products, we could raise the overall efficiency of our technological life-support systems four-fold.[26] Many products can be made five, ten, even one hundred times more efficient in their use of materials and energy.[27]

Examples of more with less are ubiquitous: from our shrinking computers with more and more power and functionality, to the more fuel-efficient vehicles, heaters, refrigerators, washers, and homes are just a few. The principle of "doing more with less" is fundamental to design science problem solving. It offers a way to take care of all of humanity's evolving needs with ever fewer resources per person. Without it, we will not be able to take care of eight or more billion people at a standard of living that we would all desire.

One way to measure human progress is to chart our ability to do more with less. As we learn more, our understanding of systems in nature increases our ability to get more useful units of life-support for more

24 R. Buckminster Fuller, *Utopia or Oblivion: The Prospects for Humanity* (New York: Bantam Books, 1969).

25 Robert U. Ayres, "Industrial Metabolism," in *Technology and Environment*, ed. Jesse H. Ausubel and Hedy E. Sladovich (Washington, D.C.: National Academies Press, 1989), https://doi.org/10.17226/1407. p.26 estimates only 6% of the annual accumulation of active materials gets embodied in durables

26 Ernst U. von Weizsacker, Amory B. Lovins, and L. Hunter Lovins, *Factor Four: Doubling Wealth, Having Resource Use* (New York: Earthscan, 1997).

27 Paul Hawken, ed., *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming* (London, UK: Penguin Books, 2017)., p.12

people with less investment of resources per unit. If our technological systems are a reflection of our understanding of the principles of nature, then waste and inefficiency in our use of resources, disregard for our environment, and neglect of impoverished populations, are reflections of ignorance.

Because we do not learn less, each time resources are employed to do a given task, processes can often be designed or redesigned so that more is accomplished with the same quantity of resources. For example, recent smart phones have 5,000 times the computing capacity of a 1980s Cray-2 supercomputer, weigh 5.78 ounces (163 g) versus 5,500 pounds (2,500 kg), and occupy 1.6 square inches (10 cm^2) versus 16 square feet (15,000 cm^2). A Cray-2 as powerful as the iPhone 12 would weigh 27.5 million pounds (12,500,000 kg).[28]

In 2019, 27% of the global population lived below their country's societal poverty line (SPL), but the incidence in 2022 is expected to be higher, as a result of the COVID-19 pandemic.[29] Looked at from another perspective, Earth's resources, which now adequately support 65 to 80% of humanity,[30] need to be employed to support 100%. The only way of doing this–without draconian reductions in quality of life and choice, or drastic, genocidal, reductions of human population–is to do more with less.

Making everyone win

Design science solutions result in whole system performance improvements and "winners" in government, civil society, corporate, family, and individual areas. *Everybody wins* solutions do not take from the rich to give to the poor (redistribution), or trickle down from the rich to the poor. They involve a fundamental redesign of society's systems so that everyone is better off.

Human time is an important resource which can be divided into two groups: *coerced time*, which is the time an individual spends doing those tasks essential to his/her survival (eating, sleeping, getting food, etc.); and *reinvestible time*, which is the time we have free to invest in thinking, learning, and designing. The design scientist is concerned with minimizing coerced time and maximizing the total reinvestible time of humans by finding ways of meeting basic human needs, and by providing productive ways for people to use their reinvestible time. Looked at this way, the concept of reinvestible time becomes a metric for measuring wealth and the value and efficacy of a given problem solving design science strategy.

28 Adobe Acrobat Team, "Fast-Forward — Comparing a 1980s Supercomputer to the Modern Smartphone," *Adobe Blog* (blog), November 8, 2022, https://blog.adobe.com/en/publish/2022/11/08/fast-forward-comparing-1980s-supercomputer-to-modern-smartphone.

29 World Bank, "Poverty and Shared Prosperity 2022: Correcting Course" (Washington, D.C.: World Bank, 2021), https://openknowledge.worldbank.org/bitstream/handle/10986/37739/9781464818936.pdf.

30 This percentage depends on how one defines "adequately supported." The World Bank estimates that 9.3% of the global population or 719 million people, lived in extreme poverty in 2020, up from 8.4% the year before. Those people are certainly not adequately supported.(World Bank. 2022).

> *"Real wealth is indestructible and without practical limit. It can be neither created nor lost – and it leaves one system only to join another—the Law of Conservation of Energy. Real wealth is not gold. Real wealth is knowing what to do with energy."*
>
> — Buckminster Fuller

Design science is not a win/lose problem solving, planning, or economic development strategy. Neither is it what is called a win/win strategy. Both of these imply a two-party dynamic, and there are always more than two players or stakeholders in any problem of global scale. Getting what the world wants is a win/win/win solution. Or more accurately, it is a win^{n} solution.

A successful strategy will have at least national, local, corporate, environmental, economic, and global winners. And, a successful strategy will ripple through all those systems, helping resolve other problems or eliminate the causes of them as adequate nutrition eliminates many health care problems caused by lack of food, and adequate health care increases the productivity of economic systems as workers are absent less from work due to illness, and renewable and clean supplies of energy lessens the global buildup of carbon in the atmosphere and global warming.

Another aspect of the "everybody wins" principle is that overall trends of general economic improvement ("GDP is growing at 3% per year;" "the economy is booming!" etc.) are, at best, only a first order indicator of economic health. At the macro level, they do not distinguish between 'goods' and 'bads'; for example, when there is a car accident, GDP goes up.[31] These macro indicators need to be seen in the context of local micro economic health indicators. If social indicators of wealth go up but there are pockets of poverty where these trends do not hold, we are all impoverished just as your heart, brain, and nervous system might be in great shape, but if there is a cancerous growth in your lungs you are not healthy at all.

Ensuring Transparency

Transparency in the design science process is the publicly visible display of all actors and their roles, decisions, costs, resources, expenses, impacts, assumptions, goals, and accounting. All government processes, decisions and actions, as well as business practices, industrial processes, environmental impacts, and accounting of ingredients, waste and costs must be subject to open disclosure and public access.

Transparency has a power in and of itself. In decision-making and problem solving, transparency will go further toward getting what the world wants than any number of laws.[32] For example, in the US,

31 Even Simon Kuznets who developed the system of national accounts now used by all countries to measure their Gross Domestic Product and national income warned against the misinterpretation of national income as a measure of well-being. Peter A. Victor, *Escape from Overshoot: Economics for a Planet in Peril* (Vancouver, BC: New Society Publishers, 2023).

32 Ann Florini, "The End of Secrecy," *Foreign Policy* 111 (1998): 50–63.

the little known rider in the first Superfund bill (passed to clean up toxic waste sites), called the Toxic Release Inventory, mandated that every business site in the country had to disclose the chemicals that they were using and disposing of in their manufacturing and business processes. And critically they had to disclose this information to everyone, including the people living down the street or downwind from their site. This enforced transparency, the public knowledge of what was happening regarding toxic chemicals, *by itself* without the aid of additional laws outlawing or restricting these chemicals resulted in a reduction of toxic emissions by 49% from when the program was initiated in 1987 to 2005.[33]

When everyone knows the budget numbers it's hard to hide corruption. And because they are so important to the capacity and well-being of the world, this principle needs to be applied to governments and corporations, as well as intergovernmental, non-governmental, and religious organizations and their activities, funding, and accounting.

Building capacity, not just solving problems

> *"We are continually faced with great opportunities which are brilliantly disguised as unsolvable problems."*
>
> — Margaret Mead

Every problem has hidden in it an opportunity so powerful that it dwarfs the problem. Design science is more about building capacity than it is about solving problems. We need to see "problems" not as something that needs to be "solved," but as a symptom of something larger— the need to enlarge the capacity of a system. Another way of looking at this is to say that we need to focus on creating wealth, not just reducing poverty. When we focus on building capacity, it becomes apparent that wealth is in the whole, not the parts.

> *"Reformations and transformations are not the same thing. Reformations are concerned with changing the means systems employ to pursue their objectives. Transformations involve changes in the objectives they pursue . . . there is a difference between doing things right (the intent of reformations) and doing the right thing (the intent of transformations)."*
>
> — Russell Ackoff

Example 1: If the "problem" is that someone is hungry, the conventional "solution" is to get that person some food. Through building capacity, you expand the system's ability to provide food and the hungry person's ability to obtain it.

Example 2: The problem is a shortage of electric energy in a city. The standard solution is to build another large power plant. In capacity building, however, we look at the entire energy system and

33 Janet Pelley, "EPA Proposes to Relax TRI Reporting Rules," *Environmental Science and Technology* 39, no. 23 (December 1, 2005)

the regional and national systems of which it is a part, and see how they could be made more efficient, resilient, reliable, safe, and affordable. The emphasis is on how to build up the energy system's capacity and "health," not just its output. Demand as well as supply is a part of the system. Improvements in production and distribution efficiency, lowering of demand, decentralized or distributed production, and more efficient end users are all part of the capacity-building equation. The end result might be the same in this case —electricity for more people in the city— but the system with more overall capacity is stronger than one with just an additional power plant.

Example 3: The problem is not enough sales. The "solution" is to knock on more doors to get more sales. A regenerative development approach would expand the capacity of the system to get more sales: go on the Internet, market to other countries, try to improve the product you are trying to sell, and examine the needs of the system you are selling in for ways to expand its capacity. Building capacity focuses efforts on the context of so-called problems; it helps us to understand a challenge by understanding the system it fits into. By expanding capacity, we deal with the conditions that give rise to the problem instead of treating symptoms.

General systems theory pioneer Ross Ashby provides another view on this in his *law of requisite variety*, which states that a system, in order to survive, must be designed to have a greater capacity for change than the processes of the environment that affect it.

Focusing on design, not politics

> "You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."
>
> — Buckminster Fuller

If politics is the art of the possible, design science is the art of making the impossible real. That is, the design scientist sees what is needed, not what is just expedient or politically easy, and figures out how to make it happen. It starts with a vision of what is needed, not what is popular. Design science seeks to find or design an artifact that solves a problem or builds the capacity of a system in such a way that the source of the problem is eliminated. Design is a way around the power structure or status quo. Instead of fighting it in a bloody revolution to redistribute the world's wealth more "fairly", a design revolution could make the poor as wealthy as the richest person through providing better-designed artifacts for living. [34]

34 Medard Gabel, "Buckminster Fuller and the Game of the World," in *Buckminster Fuller: Anthology for a New Millenium*, ed. Thomas T.K. Zung (New York: St. Martin's Press, 2001). For a more through explication of Fuller's design methodology see: "Universal Requirements for a Dwelling Advantage" in R. Buckminster Fuller, *No More Second Hand God* (Carbondale, IL: Southern Illinois University Press, 1962). and, "Design Science Event Flow" in Fuller, *Utopia or Oblivion: The Prospects for Humanity*.

Designing for regeneration, not sustainability

One way of looking at "sustainable development" is that it is a half-vast approach to vast problems. Its purpose —to make life on this planet sustainable— is, in some circles, a noble disguise for the maintenance of the status quo. Sustainable development needs to be about creating a society that can be sustained and further developed, not about sustaining the society we have.

When the status quo includes hundreds of millions of acres of degraded to destroyed farmland and leveled rainforest, depleted to exhausted fisheries and aquifers, toxics choked streams, decreasing biodiversity, and a changing climate, *sustainability,* if it means maintaining what we have for future generations, is simply not acceptable. In short, sustainable development is like the bromide, "do no evil;" it does not set the bar high enough. We can, and need, to do better than just sustain the unacceptable or accept the present as the best we can do.

The latest improvement on sustainability is the concept of "zero emissions". Here it is not acceptable to produce just enough waste to not overwhelm nature's capacity to recycle our industrial by-products. The goal is to produce our goods and services in a way that there are no wastes so that the by-products of one industrial process become the inputs for another process. In this industrial ecology we connect the waste streams from one industrial plant to the input channels of another thereby turning waste into resources. This is another noble goal, and a huge improvement on the basic notion of sustainability but we can do better than zero.

Beyond sustainability and zero emissions

Our local and global problems and visions for what we want needs to be viewed in the context of *regenerative development*.

Development is the use of resources to improve the well-being of a society. What is called sustainable development is the use of resources to improve society's well-being in a way that does not destroy or undermine the support systems needed for future development. Regenerative development is the use of resources to improve society's well-being in a way that builds the capacity of the support systems needed for future development. What sustainable development is to traditional economic development, regenerative development is to sustainable development.

To take one example: "sustainable agriculture" refers to a process of producing food that does not degrade the ecosystems on which agriculture depends. It seeks to farm in ways that keep soil erosion at "replacement" levels. In this way, future generations will be able to farm the same land. This is a huge improvement over traditional, soil-erosion intensive farming, *but does not go far enough.* It is now technologically possible and economically competitive to produce food while simultaneously leaving the plot of land better off to farm in ways that not only leave roughly the same amount of soil after harvest, but to increase the quantity and quality of soil after harvest; that is, to farm regeneratively.

Regeneration builds capacity; sustainability, at best, maintains it.

Regeneration can work across all development sectors, not just in agriculture. Every problem confronting global society can be approached through the regeneration model. The question in sustainable development is "How can we solve this problem in such a way that we sustain or do not hurt the underlying support systems?" The question in regenerative development is "How can we solve this problem in such a way that we improve the capacity of the underlying support systems?" How can we meet our needs and develop our economy in ways that result in more rain forests, more fertile soils, restocked fisheries, clean and abundant aquifers and streams, a cleaner atmosphere, and even more biodiversity?[35] After we have met our needs for basic life support and the additional goods and services that modern society identifies with the myriad and evolving definitions of the "good life" how do we do all that in ways that make our life-supporting infrastructure stronger, more resilient and diverse, deeper and more *alive* than it was before we showed up? *That* is the challenge facing humanity in the 21st century, not how do we preserve what remains of our dwindling stocks of ecosystem infrastructure.

Regenerative development also seeks to increase the efficiency and capacity of our industrial and technological metabolism while providing life-support services and products for the world's population. Like zero emissions sustainability, it seeks to close all the open loops spewing waste into the environment and direct these resources to places in the industrial metabolic system where they can become valued inputs. The goal is to reduce waste and close valves that allow valuable chemistries to flow out of the industrial system into natural systems, where they become known as "pollution." Regenerative development goes further.

Designing for development, not growth

> "If we stop thinking of the poor as victims or as a burden and start recognizing them as resilient and creative entrepreneurs and value-conscious consumers, a whole new world of opportunity will open up."
>
> — C. K. Pralahad

> "Economic growth in the Third World is an opportunity, not a threat; it is our fear of Third World success, not that success itself, that is the real danger to the world economy."
>
> — Paul Krugman

35 Bioengineering, genetic engineering are here to stay. Focusing them on restoring lost species, rather than cloning new " Frankensteins" is a more regenerative path for this science. Incentives need to be established for this use of genetic engineering.

Design science seeks to solve problems by transforming society, not merely enlarging it. Growth is an increase in size or number. Development is an increase in competence and quality of life. The ability to satisfy human needs and desires and those of others is at the core of development.

Recognizing that needs are markets

> *"A necessary accompaniment to the freedom to compete and to earn profits in so doing is the duty of citizenship."*
>
> — C. Marsden, BP

The design science process seeks to harness the productive capacity of committed individuals and organizations in ways that are regenerative, not exploitative. Towards that end, design solutions are seen in the context of what contribution can be made to distributing and setting in place a regenerative solution delivery process.

In a corollary to the capacity-building principle, what we see as "problems" are markets awaiting the enterprising entrepreneur who can figure out how to meet those needs. Problems are unmet needs that can often be met through creative products matched to the real needs of real people.

Meeting the basic human needs of people in emerging markets requires that the product, and its marketing and financing, be creative and well thought out[36]. Creative, even radical marketing techniques—often in a tri-sector partnership with local NGOs and government—are as important as brilliant products.

In a world where the world's needs and problems are perceived as markets, the market economy becomes a tool for regenerative solutions. In this context, poverty is a mandate for entrepreneurial innovation and creativity, not just government intervention and paternalistic imposition of top down "solutions". Moving towards an inclusive capitalism system such as this strengthens the entire global economy. Using market forces wherever possible helps ensure that "solutions" don't arrive stillborn or disappear as soon as outside funding dries up. It is becoming increasingly clear that profitability is essential for at least economic sustainability; that profit provides the incentive needed for the kinds of effort and investment needed to make solutions successful. The need to make a profit forces solutions to be products and services that are valued by customers, and which customers will pay for. And, not incidentally, puts the customer in charge, rather than a government bureaucracy. Becoming informed, active, and involved consumers and voting with their currency, local communities invest their valuable resources in projects that benefit their families and in which they have a stake in making sure they stay viable. The poor are transformed from victims into consumers and when informed consumers are in charge, a marketplace is one of the better tools for ensuring power and control is in the hands of the community.

36 C.K. Prahalad, *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*, Revised and Updated 5th Anniversary Edition: (Upper Saddle River, New Jersey: Wharton School Publishing, 2009).

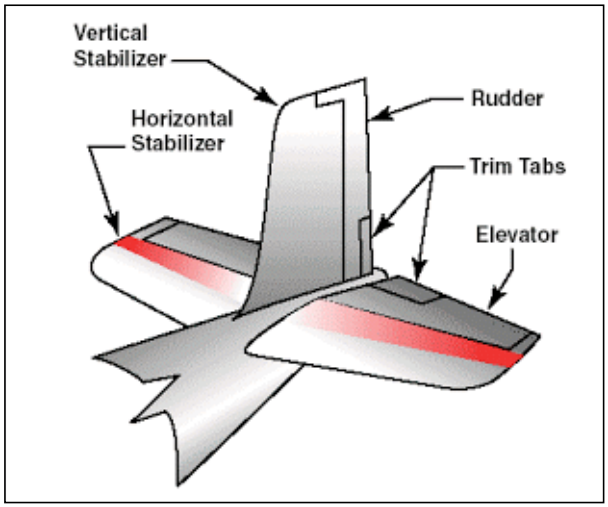
Looking for trim tabs / tipping points

"Trim tab" is a word taken from the vocabulary of designers and pilots of aircraft and ships. A trim tab is a device on the trailing edge of a ship or plane's rudder. It is, in effect, a tiny rudder on the back end of the relatively large rudder that steers the vehicle. It is very small, but it is responsible for changing the course of the vehicle because it takes advantage of the dynamic principles operating on the vessel by doing the most with least effort. When the trim tab moves, it creates a low-pressure area that pulls the larger rudder to one side, in turn pulling the trailing end of the vehicle around and changing its course.

Other metaphors are similar to trim tab. For example, "tipping points" are critical points of intervention or inflection where a small change can make a large qualitative or quantitative difference in the state of a system. These may be positive or negative. On the negative side, scientists have identified numerous potential tipping points related to climate change. They occur when change in large parts of the climate system become self-perpetuating beyond a warming threshold.[37]

Tipping points may also be called 'leverage points'.[38] "Nudges" are any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives.[39]

Trim tab is an important concept in design science. It involves determining the set of actions that can be taken to change the course of a larger system. In design science, a trim tab is the most efficient use of resources, force, and power to accomplish a desired goal. The trim tab metaphor is used to describe an artifact specifically designed and placed in the environment at such a time and place where its effects would be maximized thereby affecting the most advantageous change with the least resources, time, and energy invested.



Source: https://www.tekportal.net/trim tab

Figure 5. Trim tab on a plane.

37 David I. Armstrong McKay et al., "Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points," *Science* 377, no. 6611 (September 9, 2022): eabn7950, https://doi.org/10.1126/science.abn7950.

38 Donella H. Meadows, *Thinking in Systems* (White River Junction, VT: Chelsea Green Publishing, 2008).

39 Richard H. Thaler and Cass R. Sunstein, *Nudge: Improving Decisions About Health, Wealth, and Happiness*, Revised and Expanded (London, UK: Penguin Books, 2009).

Meldrum *et al* present a model of enabling tipping points based on affordability, attractiveness and accessibility, and point out that tipping points depend on the feedback loops that determine the behaviour of all dynamic systems.[40]

Reforming the environment, not the person

Design science does not seek to change human nature. Rather it seeks to change the environment in which humans operate, expanding their options, not limiting their choices to what someone thinks is "good". The focus is on changing the physical environment within which humanity functions, rather that attempting to reform human behavior through laws, regulations, or moral imperatives. The rationale for this approach is that it is more effective, efficient, respectful of human intelligence and diversity, and leads to greater innovation, capacity growth, and longer lasting solutions. Design science is not a religion dictating what is good behavior, but a science that seeks to expand options, thereby making self- or socially destructive behaviors obsolete and onerous.

Artifacts

A key way of reforming the environment is with artifacts. Artifacts, in a design science sense,[41] are physical and conceptual elements that change the properties of a system and its environment. They solve a problem and/or build the capacity of a system so that the problem is solved or no longer relevant.

A physical artifact is something like a wind generator, solar cell, computer, or building. It is something that takes up space, uses materials, and consumes energy in its manufacture and use.

A conceptual artifact is something like a law, regulation or standard that raises fuel efficiency standards for motor vehicles, guarantees health care, regulates work conditions and safety, establishes building codes, trade agreements and land ownership.

Both physical and conceptual artifacts are critical to the design science process, and to making the world work for everyone. They also work in tandem—even to the point of being seen as the two sides of the same coin. Either one by itself can be impotent or a dead-end. For example, a law that makes it a crime to go hungry or to only drive a car that gets over 100 miles per US gallon (less than 2.35 L/100 km), is ridiculous if there is not enough food to go around or there are no cars that get that

40 Mark Meldrum et al., "The Breakthrough Effect:How to Trigger a Cascade of Tipping Points to Accelerate the Net Zero Transition" (Systemiq, University of Exeter, and Bezos Earth Fund, 2023), https://www.systemiq.earth/wp-content/uploads/2023/01/The-Breakthrough-Effect.pdf.

41 The term "artifact" in a scientific sense often refers to something that gets into a science experiment and produces bogus results. In imaging, whether photographic, medical, or scientific, "artifact" refers to limitations of the imaging technology that results in misrepresentations of the object being imaged that are a result of the technology being used, and not reflective of the characteristic of the object being imaged. The two meanings are entirely different and unrelated other than by spelling.

level of fuel efficiency. On the other hand, having an abundant food supply in a world with starvation and hunger but no organizational way of getting this food from the farm, silo, or warehouse to those in need (such as a food stamp or school lunch program, or a World Food Program that delivers food to those in need), is equally ineffective.

In the design science approach to problem solving, problems are solved through artifacts, rather than by trying to change or reform human nature. By adding new artifacts to the world, the repertoire of responses that people have to choose from expands, thereby allowing them to change their behaviors through their own volition.

Designing for scale

"Scalability" is the capacity to grow from a "one-off" prototype or proof-of-concept design to a mass-produced society-wide deployment of a solution.

If a solution to a problem, or a product, or service for a market cannot be scaled up from the prototype stage to widespread adoption and use, it is stillborn. A brilliant local solution that doesn't scale up is only half "complete", at best. The job of regenerative development is to move good solutions from local prototype or proof-of-concept to full-scale global implementation.

Scalability works both ways: the discipline of looking to scale enriches the prototype by making it more universal, robust and adaptable. Part of any good design science solution needs to be a plan for how an artifact goes from test to prototype to widespread use, or in other words, from local to regional to global impact.

Making visible the invisible

"What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."

— Herbert Simon

Consider that the human machine, while good at decoding the basics of our immediate environment—like when it's day or night or when a creature is about to eat you—has very little talent for decoding how the rest of nature works without the tools of science. If we want to know what's out there then we require detectors other than the ones we are born with.

— Neil deGrasse Tyson

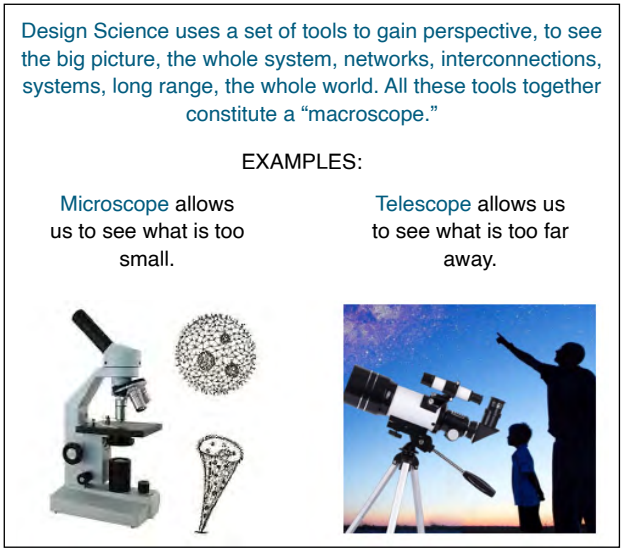


Figure 6. Extending the range of human vision.

Every part of the design science planning process requires a slightly different set of descriptive tools. Sometimes it is necessary to invent new ways of describing aspects of the system in order to understand adequately what is going on.

The following set of tools have been used to gather, organize, and make visible the information needed to make the most informed decisions about the system being considered and the possible options for a problem's resolution and reaching a Preferred State.

Our abilities to solve problems are dependent upon our ability to recognize and communicate problems and the systems of which they are a part. Because most of "reality" occurs outside the range of human senses, our ability to "make visible the invisible" is an essential part of design science.

Not only is it essential for recognizing and defining the problem, it is also needed for the communication of a design science strategy and its rationale, impacts, costs, and benefits in such a way that it is understandable by all the stakeholders who will implement, benefit, pay for, or be impacted by the strategy.

Making visible the invisible, turning data into knowledge and turning that knowledge into action that solves problems and meets human needs, is what design science is all about. This data visualization process is often achieved by graphically decelerating events that occur too swiftly to be seen or understood, or by accelerating the events that occur too slowly, or are too small or big, for our perception. The following are some of the methods by which the invisible can be made more visible.

Diagramming

Diagramming is a technique for identifying the parts of a system, showing their relationships, how they interact, and the results of those interactions. It can make visible processes and parts too big (or too small) for normal human apprehension. For example, the diagram in Figure 7 shows the parts of a wind turbine.[42] Figure 8 is a diagram showing a proposed design for electrifying a health clinic in Africa.[43]

42 Jay Baviskar, "What Are Turbines? Types of Turbines & Their Application," *MechStuff* (blog), 2018, https://mechstuff.com/turbines-types-of-turbines-applications-in-powerplant/.

43 Medard Gabel and The Global Solutions Lab, "Designs for a World That Works for All: Solutions and Strategies for Meeting the World's Needs," Vol III (Media, PA: BigPictureSmallWorld Inc., 2022), https://designsciencelab.com/wordpress/wp-content/uploads/2022/12/2022-Designs-for-a-World-Vol-III-FINAL-FOR-WEB-DEC-12.pdf.

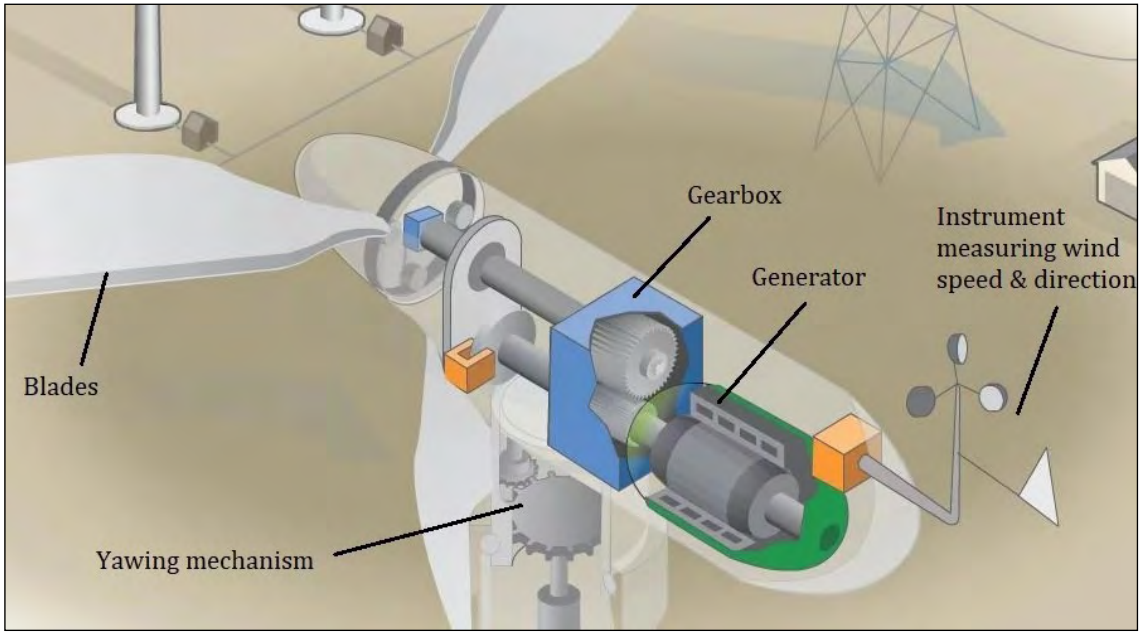


Figure 7. Parts of a wind turbine.

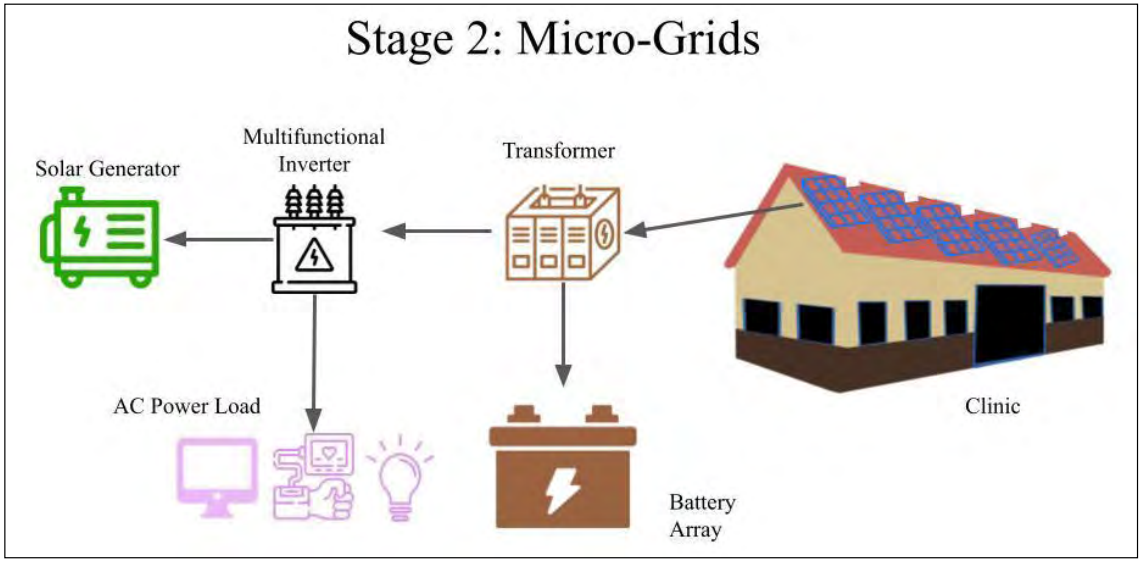


Figure 8. Proposed design for electrifying health clinics in Africa

VISUALIZING DATA

VISUALIZING DATA is a about presenting data about things like problems, resources, technology, environment factors and human needs in a way that helps in understanding those data and in communicating those data to others. The specific form of the visual will depend on the type of data, and the type of understanding that is being sought. Relationships may be indicated via scatter diagrams, trends by time series, and geographic data by maps. We need to be very careful about how we choose to present the data to ensure that we do not mislead ourselves or those we are communicating to. We want to minimize the 'lie factor'.[44]

$$Lie\ factor = \frac{size\ of\ effect\ shown\ in\ graphic}{size\ of\ effect\ in\ data}$$

Tufte lays out six principles for graphical integrity:

- The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented.
- Clear, detailed and thorough labeling should be used to defeat graphical distortion and ambiguity. Write out explanations of the data on the graphic itself. Label important events in the data.
- Show data variation, not design variation.
- In time-series displays of money, deflated and standardized units of monetary measurement are nearly always better than nominal units.
- The number of information-carrying (variable) dimensions depicted should not exceed the number of dimensions in the data.
- Graphics must not quote data out of context.

All data display— including charts, graphs, and maps— reflect the world view and bias of the person or organization that develops the display. For example, viewing world population from 5000 BC to 2000 AD suggest a vertical trajectory in recent years, as illustrated in Figure 9, whereas if we only consider population from 1980 to 2000, it appears only as a gradual increase, as illustrated in Figure 10.

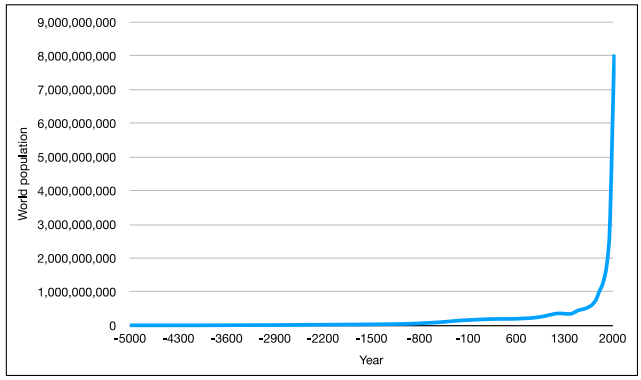


Figure 9. World population from 5000 BC to 2000 AD

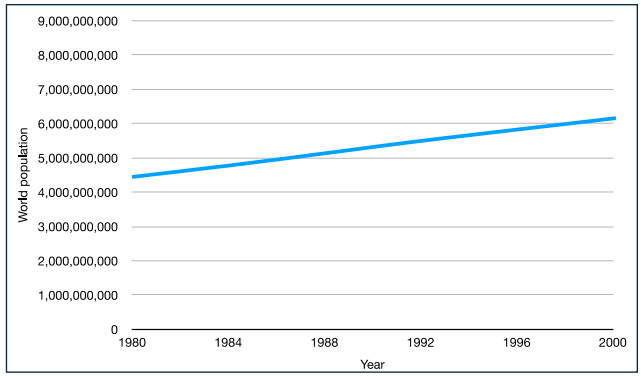


Figure 10. World population from 1980 to 2000

44 Edward R. Tufte, *The Visual Display of Quantitative Information*, Second Edition (Cheshire, CT: Graphics Press, 2001).

Trends of key variables

Charts or displays showing changes of key variables measurements over time can help in understanding the system under consideration. For example, Figure 11 shows the trend over time in armed conflict.[45] Evaluation of trends should consider the causes and consequences of what is being seen. .

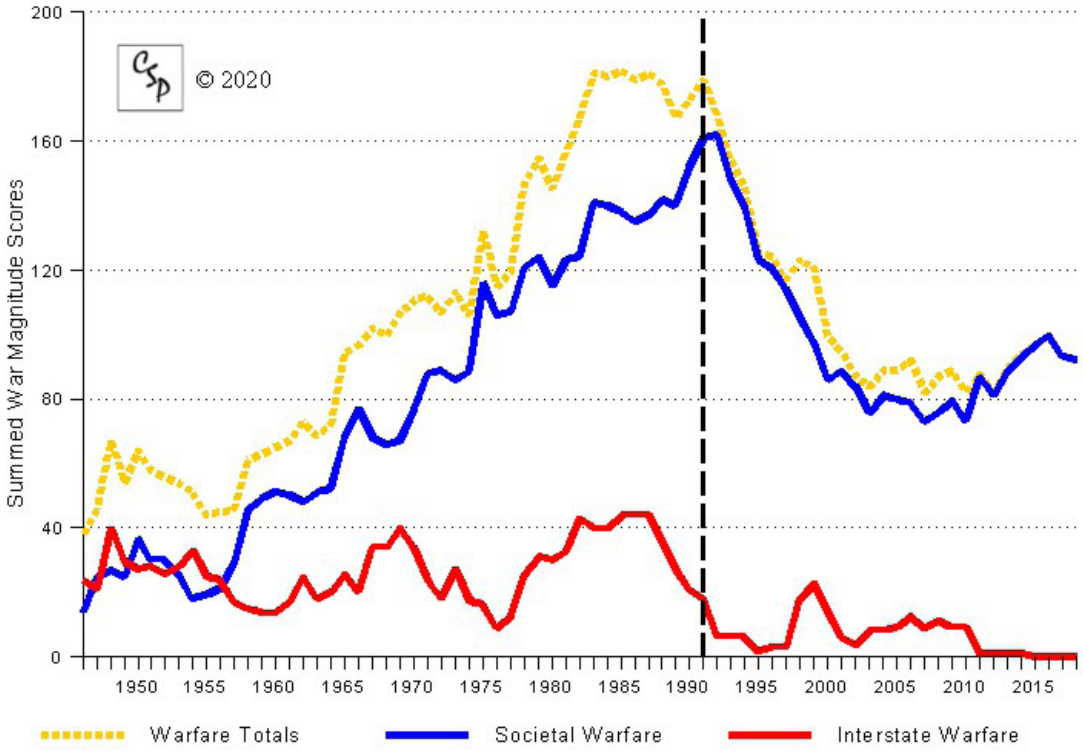


Figure 11. Global trends in armed conflict: 1946 - 2019

Correlation

It may also be helpful to show the relationship between two variables, as in Figure 12, which shows how emissions of greenhouse gases per capita corresponds to income per capita across countries. It is important to remember that correlation is not the same as causation; in the case of the variables considered, a major objective of all countries party to the Paris Accord is to reduce the emissions per unit of gross domestic product.

45 Center for Systemic Peace, "Global Conflict Trends: Assessing the Qualities of Systemic Peace," Center for Systemic Peace, 2020, https://www.systemicpeace.org/conflicttrends.html.

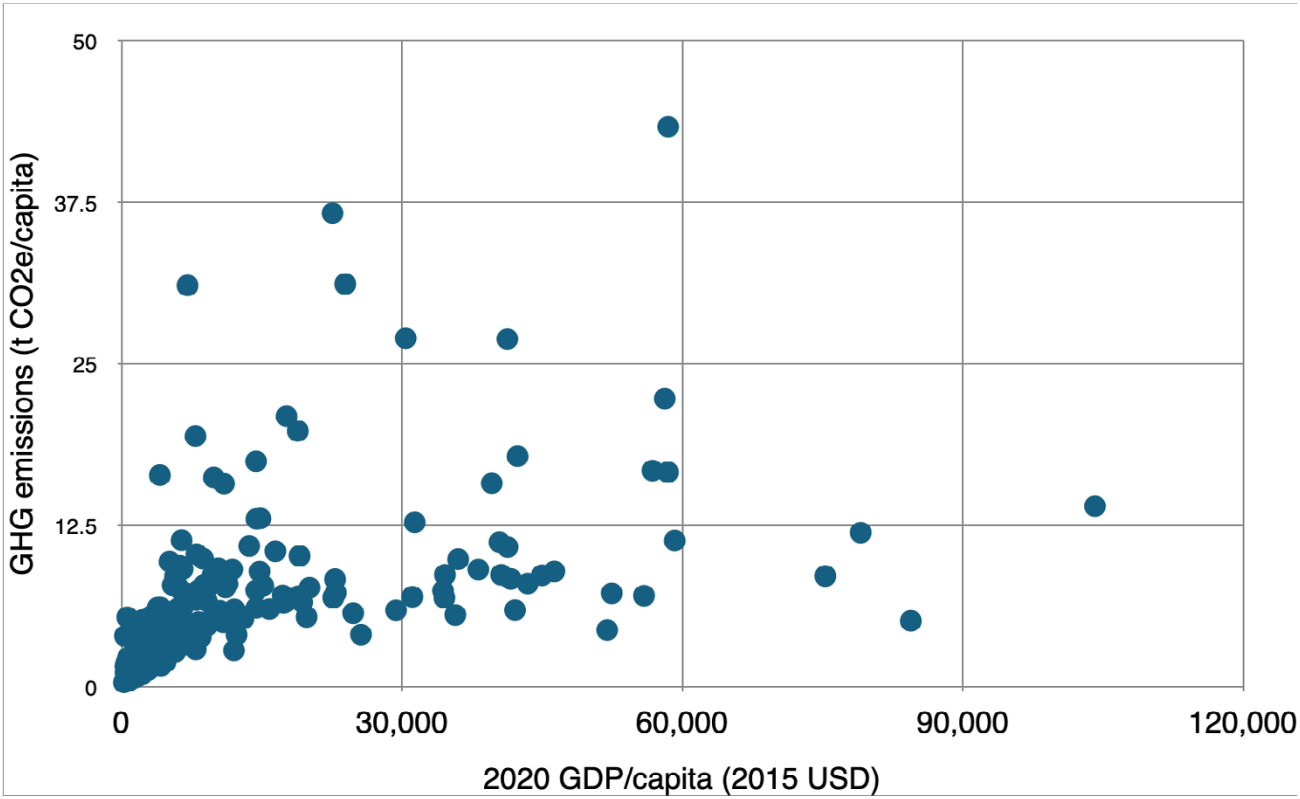


Figure 12. The relationship between per capita GDP and per capita emissions of greenhouse gases. Each dot represents a country. (World Bank data for 2020)

Mapping geographic data/location/distribution mapping

Data connected to geography may be displayed on maps to demonstrate the shape, size, pattern or location of events and their relationship to the environment. This method permits recognition of special relationships that might not be visible in charts.

Maps covering the whole world have the challenge of displaying a sphere on a flat piece of paper, which inevitably introduces distortions. Different types of maps for different purposes address this in different ways. For example, where it is important that the data being displayed are on a map that shows the shape and size of continents that are close to their shape and relative size on Earth, Buckminster Fuller's world projection is the most appropriate. It is the least distorted two-dimensional map of the whole Earth.[46] (See Figure 13 and Figure 14.).

46 See https://www.bfi.org/about-fuller/big-ideas/dymaxion-map/for more information.

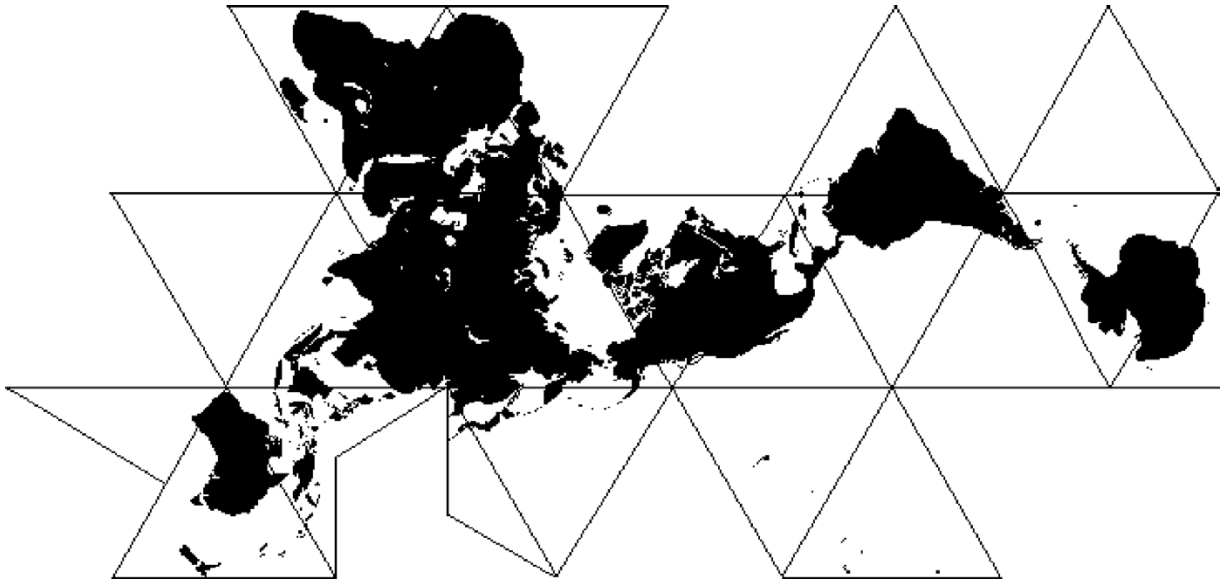


Figure 13. Buckminster Fuller's world map projection. Relative sizes and shapes of continents are more accurate in this projection than in other map projections.

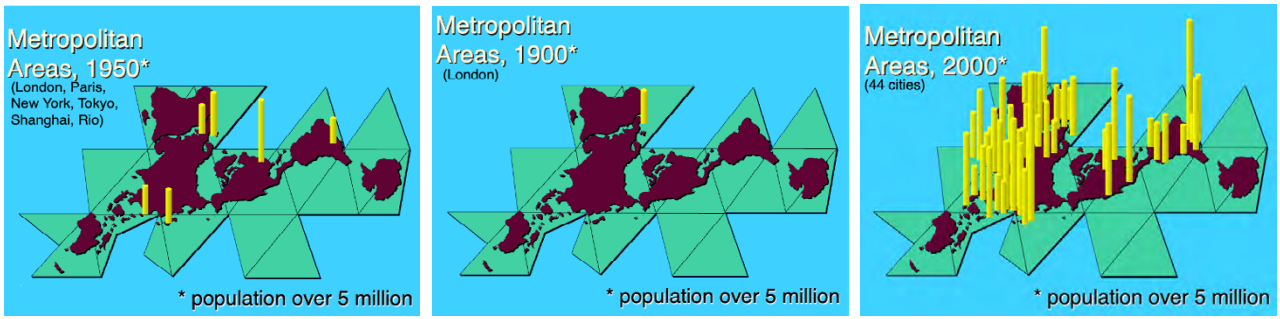


Figure 14. Growth in the number of metropolitan areas with populations over 5 million between 1900 and 2000 shown on the Fuller projection projection.

In other cases, it may be desirable to distort the size of a geographic area in proportion to the variable being plotted. For example, in Figure 15, the size of geographic areas on the map are sized in proportion to that region's greenhouse gas emissions.[47] As the largest emitters, China and the United States are the largest areas on the map.

47 WorldMapper, "CO2 Emission in 2020," WorldMapper, 2022, https://worldmapper.org/maps/co2-emissions-2020/.

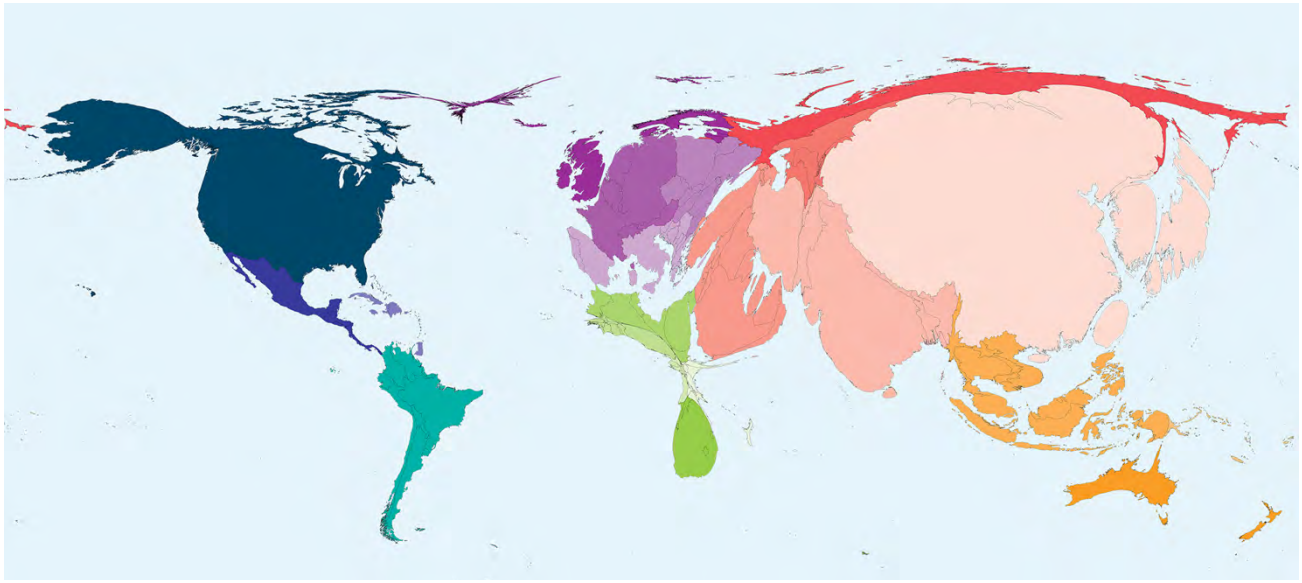


Figure 15. Cartogram of greenhouse gas emissions in 2020. Geographic areas are scaled in proportion to their greenhouse gas emissions.

Many other projections are available and may be suitable in some contexts.[48]

In addition to these relatively flat, non-dynamic displays of data, it is also possible to show changes in data over time as a movie. For example:

1. A movie on world population over time dramatically demonstrates the growth in population in recent years. https://worldpopulationhistory.org/map/2050/mercator/1/0/25/
2. Gapminder's tool for animating data allows the user to see changes in multiple variables, by country over time. https://www.gapminder.org

Modelling

Modelling is a technique for representing the state of a system and how its components interact. It is a simplified description of reality that is designed to yield hypotheses about the behavior of what is being modeled that can be tested.[49] Some models are 'mental models', which are mental frameworks or representations of how something works. Other models may be represented in other mediums, such as physical or computer models.

48 Benjamin Hennig, "A Brief Look at Map Projections," Views of the world, August 9, 2010, http://www.viewsoftheworld.net/?p=752.

49 Sam Ouliaris, "What Are Economic Models? How Economists Try to Simulate Reality," International Monetary Fund, *Back to Basics V48N2* (blog), June 2011, https://www.imf.org/external/pubs/ft/fandd/2011/06/basics.htm.

A commonly used simple model is '*trending*', which is plotting data about particular aspects of a system over time, allowing the design scientist to perceive patterns of change occurring too rapidly or too slowly to be evident by direct observation.

Computer models can be manipulated to test the validity of the underlying variables which make up the model. Such models can be systematically explored, altered and tested against the real world until they are an accurate representation. They are most useful in exploring sensitivities to change and calculating the consequences of interactions over time.

Computer models are also well suited for addressing complex systems and their interactions. These include economic models[50] (see Figure 16), global system models[51] (See Figure 17) and ecosystem and energy models[52] (See Figure 18).

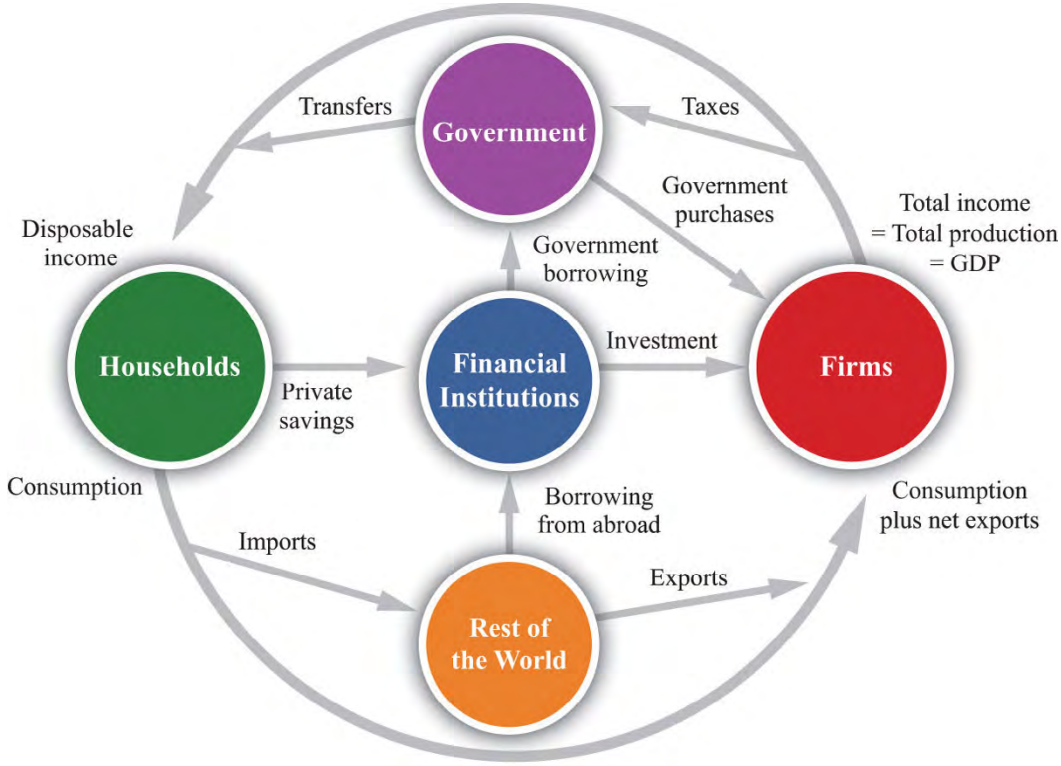


Figure 16. Traditional economic model of an economy

50 Conspecte Team, "The Four Sectors of the Economy," *ConspecteCom*, 2020, https://conspecte.com/en/Economics/the-four-sectors-of-the-economy.html.

51 Sandrine Dixson-Declève et al., *Earth for All: A Survival Guide for Humanity*, A Report to the Club of Rome (Gabriola Island, BC, Canada: New Society Publishers, 2022).

52 Howard T. Odum and Elisabeth C Odum, *Modeling for All Scales: An Introduction to System Simulation* (San Diego, CA: Academic Press, 2000).

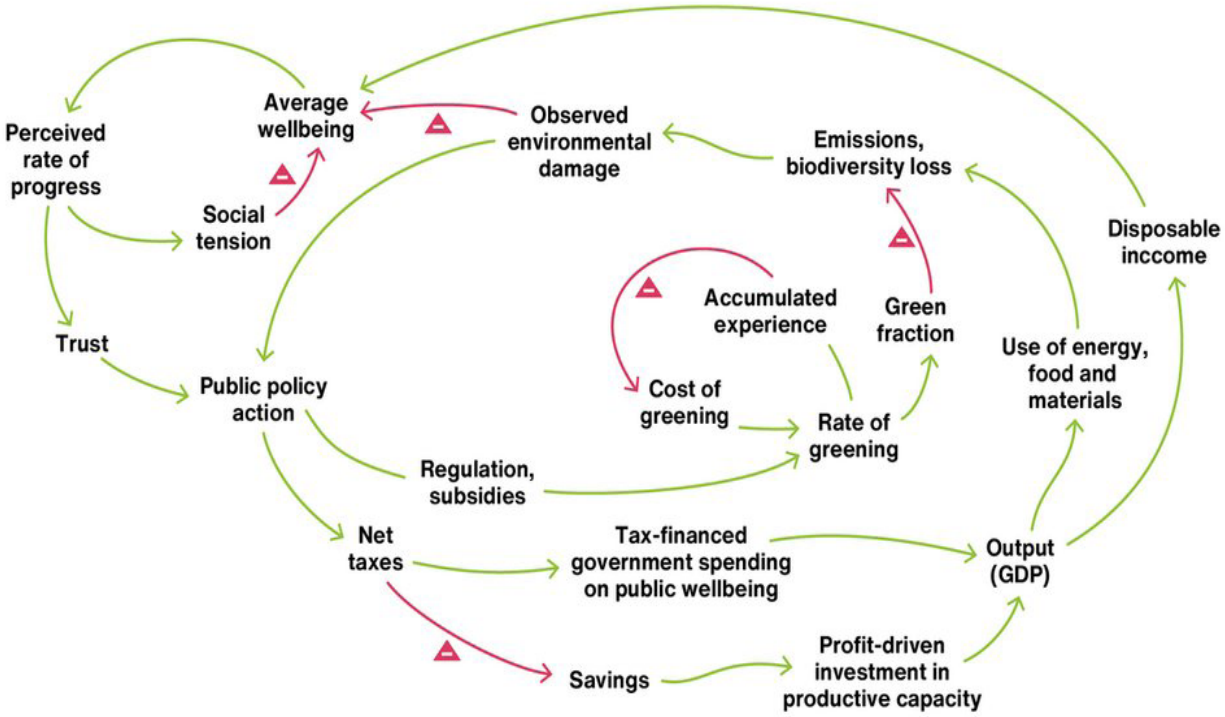


Figure 17. Simplified version of the model used in Earth for All.

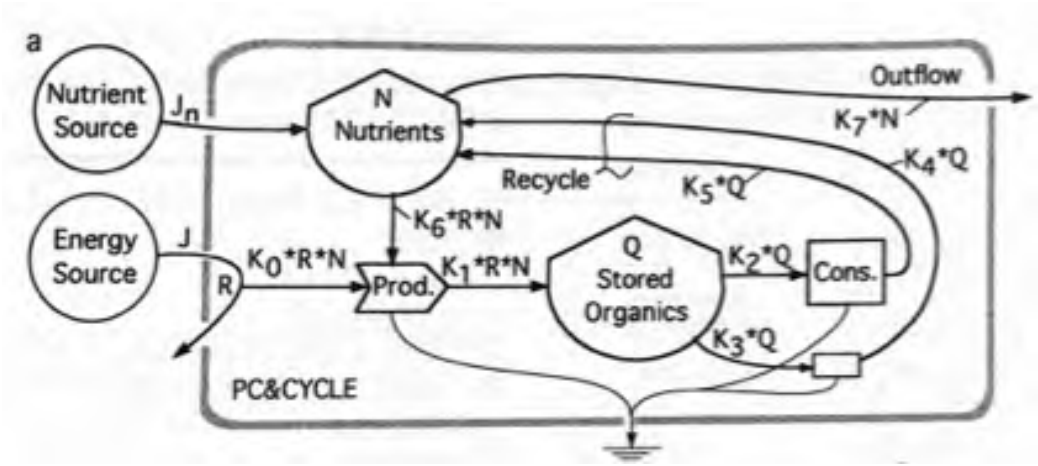


Figure 18. Model of production, consumption and recycling typical of ecosystems

Scenarios

Models are often used to generate 'scenarios'. One definition of a scenario is that it is a logical sequence of events (a strategy) to show how, starting from the present, a future evolutionary condition might evolve step by step. It is a synergetic synoptic view of as many developments as can be grasped and as may appear relevant to an experimental simulation of a possible reality.

Scenarios, in other words, are alternative descriptions of how the future might unfold. These may be based on alternative assumptions about key driving variables or may be the result of different actions that may be taken. The Present State may discuss or show the continuation of current trends as one scenario (sometimes called Business as Usual), and the design for the Preferred State may be another. These extrapolations from historic data may also be useful to show how the future *cannot* unfold, or that the existing trends are not desirable.

Both mental models and computer models may be used to generate scenarios, or stories about how the system might develop or change over time.

The further one goes out in time, the uncertainty increases. One strategy for considering this uncertainty is the use of scenarios. (See "The Future Cone" on page 9). Ideally, the preferred design will be able to accommodate any of the scenarios.

It is often helpful to plot changes in key variables underlying scenarios as a graph or graphs. Some examples of scenarios are illustrated in Figure 19 and Figure 20.

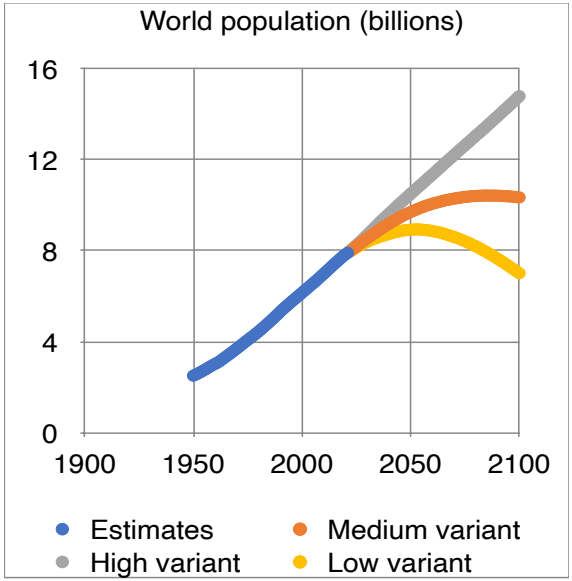


Figure 19. World population trends and forecasts to 2100.

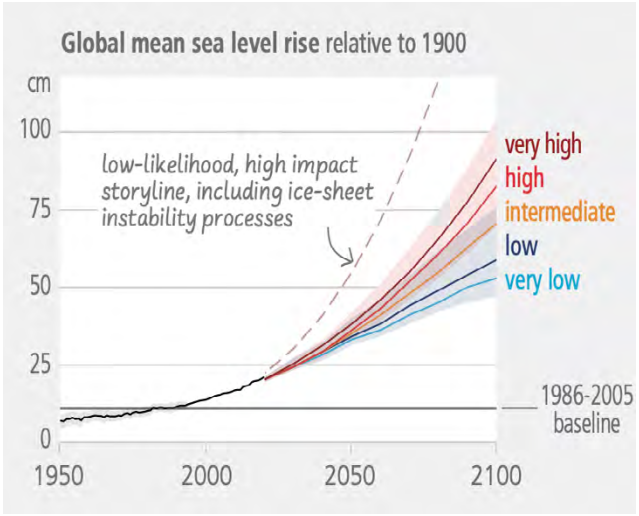


Figure 20. Scenarios show sea level rise under a range of assumptions on greenhouse gas emissions. Source: IPCC (2023)

Figure 19 shows the United Nations' global population projections based on models of population parameters, include birth rates, death rates and population age pyramid. Figure 20 shows five scenarios for sea level rise based on climate models and different assumptions of future greenhouse gas emissions prepared by the IPCC.[53]

Table 4 shows the policy interventions in one of the scenarios modeled in the model depicted in Figure 17.[54]

Table 4. Overview of policy interventions in the Great Leap scenario in the Earth for All model

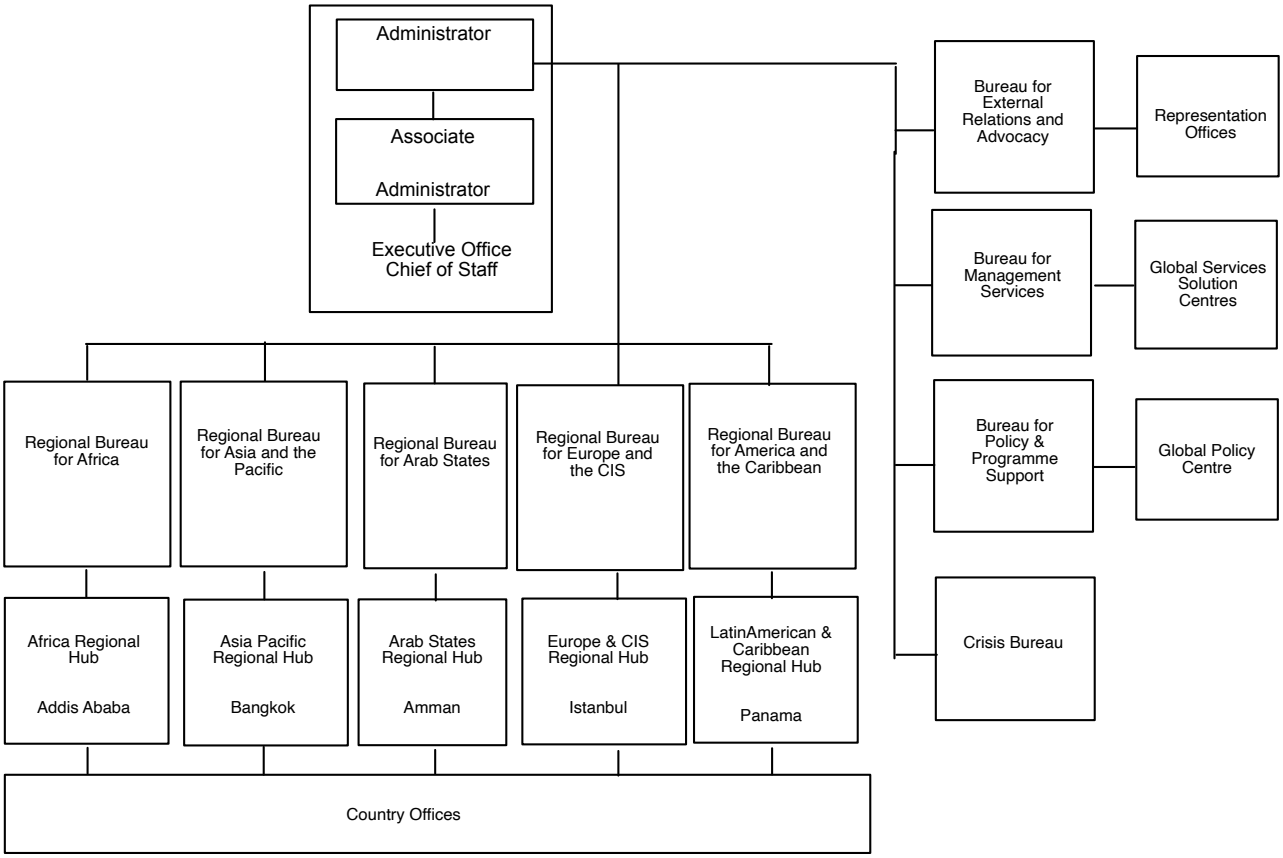
Poverty	Inequality	Empowerment	Food	Energy
Expand the fiscal space of lower-income countries Transform the current global financial architecture to expedite debt relief and improve allocation of SDRs. Transform global trade dependencies to reduce trade deficits in low-income countries Improve access to knowledge, technology and leapfrogging Develop new economic indicators	Stronger progressive taxation on both income and wealth for individuals and corporations Strengthened labour rights and trade union negotiation power. Safety nets and innovation nets to share prosperity and provide security, such as universal basic dividend.	Recognize that gender equality is essential for economic prosperity and social cohesion. Massively scale up investment to meet 2030 education targets and guarantee the right to education for women and girls. Ensure gender equality in leadership positions in public and private bodies. Guarantee universal social protection and adequate universal pension systems.	Remove perverse agricultural subsidies. Food production must shift from industrial to sustainable and regenerative agricultural practices. Localised consumption, food sovereignty and farmworker rights must be prioritized and protected. Efficiency must be improved across the supply chain.	Investment in renewables and efficiency must be tripled. Climate financing must be provided as concessional grants, not as loans. Make renewable energy affordable by redirecting fossil fuel subsidies. Support a global price on carbon and guarantee access to clean, safe and affordable energy for all.

Hierarchical organizing

Hierarchical organizing is the process of arranging data with respect to its leadership, size, shape, form, magnitude, complexity, or other quality it might possess. At the top or apex of a hierarchy is the unit, person, or organization that oversees, or is composed of all the other units or elements beneath. For example, Figure 21 shows the organizational structure of the United Nations Development Program, with the UNDP Administrator at the top of the hierarchy, and the country offices at the bottom.

53 IPCC, "Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" (Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2023).

54 Dixson-Declève et al., *Earth for All: A Survival Guide for Humanity*.



Source: https://www.undp.org/sites/g/files/zskgke326/files/2021-04/UNDP-OrgGlobal-April2021.jpg

Figure 21. The structure of the United Nations Development Program. An example of a hierarchy.

Metaphor

Metaphor or comparison – Metaphors or comparisons aid in understanding by comparing something not well known or understood to things already known.[55] For example, to understand that only 0.025% of the world's water is drinkable, one might explain "If the world's water were put into a gallon jug, humans would only be able to drink less than 20 drops of it. To explain that livestock are responsible

55 Metaphors come with strings attached, for example, the metaphor "lifeboat," when used to describe the condition of the world, (as in "lifeboat ethic") suggests that if the lifeboat is seemingly "filled" then it is necessary to keep those in the water out of the lifeboat, or else one risks capsizing the boat, and all are lost. Seeing the world as a spaceship, rather than a lifeboat, means that if there is a leak in the starboard side, we all go down. One metaphor is a rationalization for genocide, the other for seeing how everyone's fates are intertwined and for making sure everyone survives.

for 14.5% of global greenhouse-gas emissions: If cows were a country, they would be the third-highest producer of greenhouse emissions among all nations. They produce more emissions than Saudi Arabia or Australia or India and surpass every country in the European Union combined. They lag behind only China and America.[56]

Input/output analysis

I/O analysis is a chart or diagram that shows the inputs and outputs of a system. The "system" itself is simplified to a "black box" that has no parts. We can make an input/output diagram by outlining a system and listing what goes in and what comes out. This kind of chart is a good first step as it helps us get a feel for the connections the system we are looking at has with the larger system of which it is a part. *One* of the outputs should be what the system was built to produce—e.g., food if it is the global food system, electricity if it is a power plant, etc. These charts can also illustrate vulnerabilities, complexity, and intervention points.

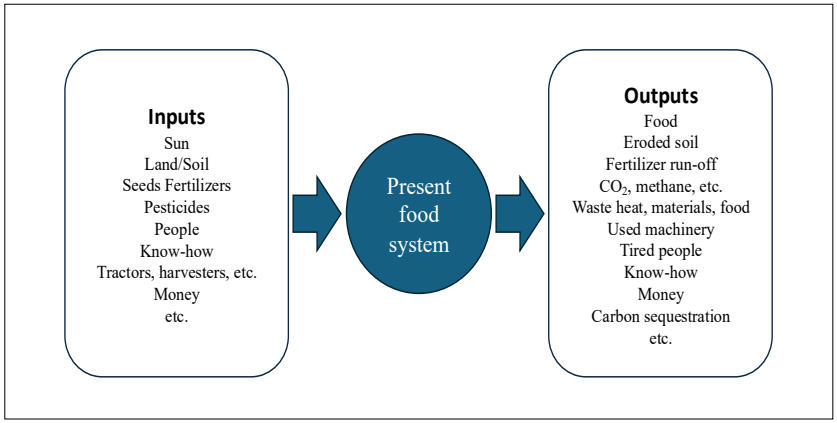


Figure 22. Inputs and outputs of the production stage of the food system

Components/processes

There are many types of diagrams that show how the different parts and processes of a system are related. Here, that "black box" from the Input/Output chart is divided into its component parts or systems. For example, your body is made up of different organs which function in different processes:

56 These examples are from Chip Heath and Karla Starr, *Making Numbers Count* (New York: Avid Reader Press, 2022). This reference provides rules for making numbers understandable, largely using comparison or metaphor.

your lungs are part of the respiratory system; the stomach is part of the digestive system; the heart is part of the circulatory system, etc.

You can make a components and processes diagram by graphically representing the system and indicating the components and processes involved. This kind of diagram is useful for understanding how the system works, and possibly learn how it could or should work (or is useless) given the task of getting to the Preferred State.

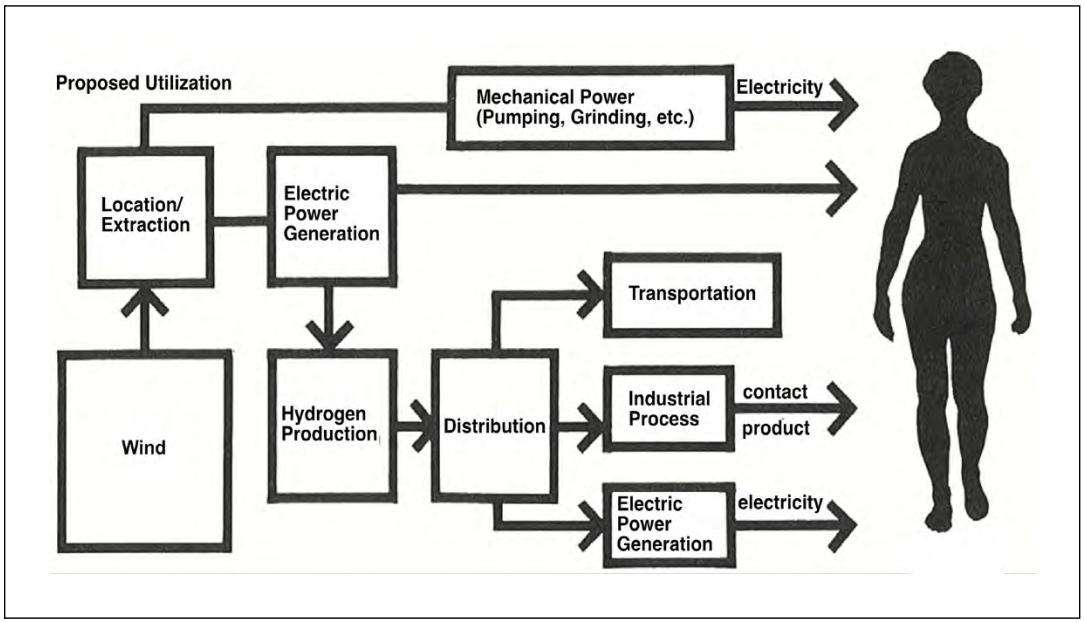


Figure 23. Process flow of wind energy from generation through to user

RESOURCES USED/NEEDED/AVAILABLE

The design scientist draws on multiple information sources that describe what material and other resources are used or needed to make and maintain the system being considered. This inventory could be from the Input/Output chart done earlier or from a listing of the materials needed for our strategic design and solution.

Such an inventory can be used to help understand and identify any limits that might exist relative to available scarce resources for an alternative to the present system. For example, early work on the feasibility of an electric grid that interconnected the entire world disclosed that such a globe-spanning grid, if it merely extended then present-day technology of high-tension power lines, would use the entire world's supply of copper and the annual output of the steel industry. Such limits do not eliminate our solution, they call for achieving our preferred state using more efficient technology.

Who does what— organizations/actors

This describes or lists the organizations or groups that work in, govern, or are necessary to the functioning of systems that make up our chosen problem situation, or that are needed for achieving our solution. This kind of listing helps us understand the human and organizational resources being used by the present system, and what could be needed for a new alternative system.

For example, if the problem situation being focused on is hunger and the global food system, then some of the organizations would be the UN Food and Agriculture Organization, the World Food Program, UNICEF, International Fund for Agricultural Development, Food First, Save the Children, IFOAM Organics International, World Resources Institute, Bread for the World, Heifer International, Feed The Children, Association for International Agriculture and Rural Development (AIARD), Mercy Corps— and others, including companies involved in food processing and distribution and other local organizations where our strategy is to be first implemented.

Impacts and interactions with other areas

Cross-impact analysis is a method to show relationships between events and variables. Although traditionally a quantitative method of estimating probability of certain events,[57] the method has also been adapted as a qualitative tool for identifying key elements of a system, and discovering new impacts and interactions.[58]

The method involves analyzing the interactions of forces, trends or decisions by constructing a two-dimensional matrix with the items being considered entered along both dimensions. The individual cells where the items meet show the relationship between each pair of forces, trends or decisions. The generic grid is shown in Table 5.

Table 5. Basic structure of a cross impact matrix. Shaded cells are usually ignored.

	Item A	Item B	Item C
Item A	A's influence on A	A's influence on B	A's influence on C
Item B	B's influence on A	B's influence on B	B's influence on C
Item C	C's influence on A	C's influence on B	C's influence on C

As an example, an initial brainstorming session on five trends might result in a matrix like that in Table 6.

57 Theodore Jay Gordon, "Cross-Impact Method," in *Futures Research Methodology*, ed. Jerome C. Glenn and Theodore Jay Gordon, Version 3.0 (Washington, D.C.: The Millenium Project, 2009), http://discoveryoursolutions.com/download_center/CROSSIMPACT.pdf.

58 John B. Mahaffie, "How to Use Cross Impact Analysis," *Foresight Culture* (blog), March 9, 2018, https://foresightculture.com/2018/03/09/how-to-use-cross-impact-analysis.

Table 6. Example of a completed, qualitative cross-impact matrix

	Growing urban population	Climate change	Pressure for alternative energy sources	Growing demand for food	Risk of pandemics
Growing urban population					
Climate change	Need for denser development and more walkable communities				
Pressure for alternative energy sources	More rooftop solar, wind energy	New energy supply to be met by carbon free sources; increased emphasis on energy efficiency			
Growing demand for food	Increase in urban food production or more transportation	Need to reduce food waste, focus on carbon sequestration	Competition for land – solar versus production		
Risk of pandemics	Concentrated population encourages spread of viruses	Expanded habitat of species carrying diseases	Pandemic curbs investment in renewables	Increased emphasis on food quality control. Elimination of wet markets	

Simulation Gaming

Simulation gaming is another method that can be used to gain an understanding of a situation. In this method the group imagines that they are in a new role and faced with a particular situation that stresses the system being examined. How will we respond?

One example of this method, used in the Global Solutions Lab, is the *Spaceship Captain Game.* This simulation has the group imagine that they are the captains of a spaceship that is in trouble. They do not know what is wrong, where their spacecraft is, or where it is going. The participants are asked, "*What do you need to know in order to identify the problems and ensure the ship's survival?*"

The responses, in the form of questions, are listed on a flip chart or white board. This exercise is very useful when learning to recognize and define problems. It helps to determine what kinds of information are necessary for general problem solving.

The following are sample responses generated by this exercise:

- How do we know there is a problem?
- What are the problems?
- How critical are they?
- Where do we find them?
- How many people do they affect and to what degree?
- What resources are available to solve the problems?
- Have these problems happened before?
- How successful were past solutions?
- What are the alternative solutions?
- How would we evaluate the proposed solution?
- How much time do we have to solve the problem?
- What happens if we do nothing?
- Where are we?
- Where are we going?
- Where do we want to be going?

Decision making criteria

Decision making criteria are the standards by which design and strategic alternatives are evaluated. There is an intimate connection between the Preferred State and the decision-making criteria. The decision-making criteria need to capture all of the elements of the Preferred State. The decision-making criteria are used for evaluating and determining which alternatives are best for achieving the Preferred State.

Key indicators

Key indicators are quantitative measures that define the decision-making criteria. Each key indicator provides a way of knowing the status of the system against each particular criterion. You can invent new key indicators by measuring characteristics of a system that you think provide an indication of its relative health, performance, longevity, or efficiency. For example, temperature and blood pressure are among the key indicators of an individual's health. Passenger distance travelled, available edible protein, energy use, population growth rate, unemployment rate, inflation rate, efficiency rating of tools are all examples of key indicators of various social and technological systems. The key indicators are useful for monitoring the health or "illness" of a given system within the Present State, as well as tracking progress (or the lack of) towards the Preferred State.

Key indicators could appear on a dashboard for a quick assessment of the state of the system being tracked. As defined by Stephen Few: "A dashboard is a visual display of the most important information to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance."[59] Figure 24 is an example of a dashboard on progress towards the Sustainable Development Goal related to energy.[60]

59 Stephen Few, *Information Dashboard Design: The Effective Visual Communication of Data* (Sebastopol, California: O'Reilly Media, Inc., 2006).

60 United Nations, Department of Economic and Social Affairs (DESA), "The Sustainable Development Goals Report 2023: Special Edition - Towards a Rescue Plan for People and Planet" (New York, NY: United Nations, 2023), https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf.

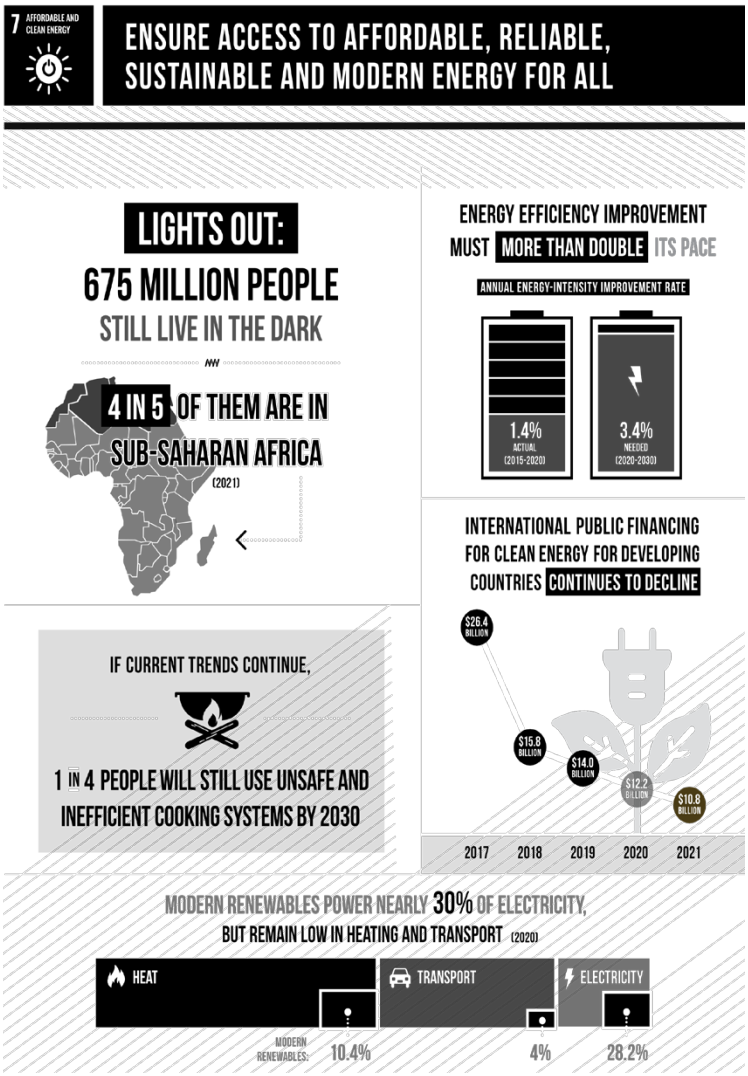


Figure 24. Potential dashboard for the SDG related to energy

The unquantifiable

> "Not everything that can
> be counted counts,
> and not everything
> that counts can be counted."
>
> — William Bruce Cameron

There may be some elements of the system under consideration for which quantitative measures are not available, but which nevertheless are important to address. These can be addressed through qualitative discussion.

What "counts" but isn't easily quantified are your values, strategic directions, goals, what should be, differing assessments of the importance of new technology and options, side-effects, secondary and tertiary impacts, differing cultures and communities' response to change, environmental costs, true costs to the global and local economy, not just those costs counted by current economics, and that all-important (and unknown) "etc.".

Resources to draw upon

Researchers, authorities, and organizations is a listing of individuals and institutions presently engaged in research and development; the people we can contact for feedback or advice on our work; and organizations which influence decisions in

different areas related to our design— or who could take our work to the next level or implement it.

Bibliography/reference is a listing of websites, links, PDFs, books, journals, articles, and other information sources dealing with the design on which we are working.

Glossary is a listing and definition of terms important for understanding the system for which we are designing alternatives. This becomes increasingly relevant for our understanding as well as in later stages of the design science process when we are communicating our strategic designs to the larger system.

Iteration

Iteration is the procedure by which we refine our design, making it better, stronger, more likely to reach our goal or Preferred State (see "Envisioning the Preferred State" on page 82). It is a process where we look over what we have done and see if the things we learned later in the design science process will change any of the things we put together in the early stages. Similarly, we look over our earlier work, for example, our goals or Preferred State, and see if there are other things we want to add, and if our design gets us to where we want to be. This review and subsequent revisions lead to results successively closer to the desired Preferred State. The new information, feedback, and insight often lead to breakthroughs that make our design jump from good, to better, to revolutionary.

Planning and design methodologies are most often portrayed as linear processes. For example, beginning with choosing the problem then following a sequence of steps to the 'solution' to the problem. In practice, each of those steps needs to be regularly revisited from time to time wherein we consider new information and understanding. Each iteration is intended to confirm or improve the earlier step, based on what has been learned in later steps.

A caution: Although iteration and refinement are an important part of the planning process, we want to ensure that we do not become so enmeshed in planning that we never get to implementation. There will always be more data to collect, more experts to consult, and more analyses to be done. As design scientists, we need to decide when the information available is sufficient to move forward— when the design feels compelling.

In the face of uncertainty, we must evaluate the best way to proceed. Are there small steps that can be taken as a probe, pilot, or proof-of-concept test? Or are the uncertainties or risks so large that further research and planning are required?

Design science is about changing the world, and therefore about action. The paralysis of analysis is a trap to be avoided. We need to know when to stop planning and to start acting.

Taking the design initiative

> "Never doubt that a small group of thoughtful, committed people can change the world. Indeed, it is the only thing that ever has."
>
> — Margaret Mead

A design scientist does not wait to be hired or receive a mandate from the status quo to develop solutions to problems. As a source of disruptive innovations, design science seeks to do what is needed, not what there is a job to do. Design science takes initiatives that set-in motion the changes needed to reach a preferred state.

Design science, somewhat unlike traditional science that seeks to understand some facet of the universe, has as its ultimate goal the taking of action that solves a basic human need problem.

The "design initiative" is the unsolicited taking on and solving of a global or local problem. Given the moral vision of design science, that is our responsibility as members of global society. To solve the problems of society, one does not wait to be hired by a government, corporation, or non-profit organization to do what is right. The design scientist sees what needs to be done and does it. The design scientist considers all of humanity the client, not just the person with the most economic wherewithal.

One of the tasks of the design scientist is to take the economic, technological, and moral initiative by designing regenerative, affordable solutions to society's problems, demonstrate their practicality and need, and place them in the environment where they can be used.

Design science brings about change through innovation—and therefore often upsets the status quo. Such disruptive innovations, or "creative trouble making" are the core of making the world's resources meet the needs of 100% of humanity.

> "The young do not know enough to be prudent, and therefore they attempt the impossible— and achieve it, generation after generation."
>
> — Pearl S. Buck

Being guided by moral vision

> "What is worthy and right is never impossible."
>
> — Henry Ford

Design science is no more about design than astronomy is about telescopes.

At the core of design science is a set of values that say that it is unacceptable for some of the people of the world to die of starvation and all other "curable"

causes of sickness and death— and the rest of us are sentenced to watch this horror via our numerous communication links. This moral vision dictates that what is "right" from a perspective of enhancing the quality and length of life for all takes precedence over what is important monetarily for the few. Meeting the basic human needs of the world trumps the accumulation of ever-larger quantities of money and shareholder value for its own sake.[61]

The moral vision of design science is based on the premises that all life on our planet is interconnected, that social and environmental justice is essential to the flourishing of humanity and our environment, and that each individual is better off when every individual is better off. It also posits that it is the responsibility of those who understand these principles to act on them.

The *design initiative* described above is based on these premises. The *moral vision of design science*, plus its practical, pragmatic problem-solving methodology, seeks to make the world work for all, meeting the basic human needs and rights of 100% of humanity, while regenerating the environmental life-support systems that make our presence on our planet possible. In other words, it seeks to make the impossible possible, practical, and profitable.

> "In a country well governed, poverty is something to be ashamed of. In a country badly governed, wealth is something to be ashamed of."
>
> — Confucius

Working in Teams

> "No one can whistle a symphony. It takes a whole orchestra to play it."
>
> — H.E. Luccock

A team of people can do more than one person working alone. A team made up of diverse people can do more than a team made up of like-minded, aged, educated, and cultured people. The whole is always more than the sum of its parts. The probability of Design Teams using the design science process presented in this book— that are international, cross-cultural, multi-disciplinary, and intergenerational— developing more visionary, inclusive, comprehensive, and implementable designs and strategies than those of a less diverse team is very high. This is *not* saying that a team composed of just students (or engineers, poets, NGO staff, etc.) cannot do great things. It is saying that diverse teams are demonstratively better— bring more experiences to bear on the problem being focused upon, than non-diverse teams. Therefore, seek to maximize the team diversity.

61 This is not a screed against capitalism or the market economy. Design science sees both as powerful tools for creating and distributing wealth. It is rather a setting of moral priorities.

It is important to make sure our design team has as much diversity of backgrounds and experience as possible. Designs for solutions and strategic plans for their implementation will be immeasurably better if the team developing them using the approach presented in this book is multi-disciplinary, cross-cultural, international, and inter-generational. The more people looking at the problem situation from different angles with differing perspectives, values, vision, and experiences the better will be the resulting design's comprehensivity, clarity, appropriateness, and long-term viability.

Group Methods for Developing Solutions

Our defining and analyzing of the Present, Problem, and Preferred State will generate a series of questions that need to be answered. What, when, where, how, and how many are all likely to come up. We need to answer these questions, for in the answers lie potential solutions and the path to the Preferred State.

In our group, ask one of the key questions that needs to be answered. After the question, brainstorm what information sources we would use to find the answer. How would we find the desired information if we couldn't find it through Google or another search engine? What is the ultimate (or primary) source for the data we are seeking? Test the different sources and determine which ones lead to the answer most readily and in which we have the most trust. After running this exercise many times, it is possible to develop a good list of the best sources of data (or sources of sources of data) for use in design science research.

Group Priority Setting

Group priority setting is a method of reducing the many views generated by a group by building consensus. Start this exercise by asking the participants to list what they think are the most important characteristics of the Problem State. Next, compile these lists to make a master list of all the responses. After this, the group can discuss the appropriateness and priority of each statement. Then, as a group, decide on the most important statements.

DATA ACQUISITION GAME is a method for learning where to find sources of various data. How it works: Each member of a team asks a question about a specific data point. For example: How many bicycles are there in Australia? How much milk is consumed in Mexico? Where do date palm trees grow? The idea is to stump the other members of the team.

AI AS A TOOL FOR DEFINING THE PROBLEM AND DEVELOPING SOLUTIONS

Large language models (LLMs) are a relatively new type of artificial intelligence (AI) and are now available to everyone with Internet access. They are a general purpose and powerful tool that can assist in nearly all facets of the design science process. One way of viewing this tool is to see AI as another member of your team.

AI works well as a generator of ideas and options. It is good at volume. Not necessarily *good* ideas but lots of them—and buried within the many might be a good to very good idea, or one that will trigger a new idea in your mind, or some ideas that working together will be great combinations.

There are things LLMs is not going to be good at— your personal values and sense of what is important. Your personal background, experiences, values, feelings, and understandings determine what problems about which you feel strongly and decide to work on— and what the goals or preferred state should be for the problem you are addressing. Your values will be broader, more inclusive, diverse, and "out-of-the-box" of established thinking and the literature on which the AI has been trained. Therefore, we want to start the process with your team's perspectives and values, and then supplement this with the spectrum of literature on which the LLM has been trained.

The key ingredient, at this point in LLMs development, is to ask the right questions, to pose the best "prompts", that will shed light on what we are looking for. Each stage of the design science process needs different prompts to elicit the most useful results. Example AI prompts are interspersed throughout the *Tools for Changing the World* where they may be helpful.

Users of these systems find it is helpful to start with general prompts, and then make them more specific, for example by specifying the writing tone or prospective audience (e.g., respond using an academic tone, or using vocabulary that will be understandable to a certain reading level), the length (e.g., make it five paragraphs long), whether to include references, and whether these should be limited to references in the past five years, or other suggestions for narrowing or broadening the answer to better meet your needs. [62]

Users of these models quickly learn how to improve the results they generate with modest practice.

Alerts:

1. Sources for answers requiring the most up-to-date statistical data might not be available. It will depend on when the model was last updated. If this is the case, settle for what is available and then go to the latest statistical document. A good starting place is to check the *Tools for Changing the World's* Appendix 2: Global statistical data sources and data analysis tools. These will take you to the latest available data.
2. The current state of LLMs is evolving rapidly. Whatever is written here needs to be viewed in

62 Ethan Mollick, "A Prosthesis for Imagination: Using AI to Boost Your Creativity," *One Useful Thing* (blog), January 28, 2023, https://www.oneusefulthing.org/p/a-prosthesis-for-imagination-using.

this context— it most likely will be at least a bit out-of-date by the time you are reading this. Nevertheless, this introductory overview should be helpful as a place to start.

3. Remember that each question/prompt for the LLM is an exploration. If you don't get an answer that is helpful, prompt in a different way. Invest some time in "prompt engineering"— editing and playing with prompts to come up with the results you want.[63]

The next part of *Tools for Changing* the *World*, the methodology section, is intended to help you take the design initiative. It is a step-by-step guide to the design science process.

63 Ethan Mollick, "How to Use AI to Do Practical Stuff: A New Guide," *One Useful Thing* (blog), March 29, 2023, https://www.oneusefulthing.org/p/how-to-use-ai-to-do-practical-stuff.

PART 3

THE DESIGN SCIENCE PLANNING PROCESS

Part 3 Design is not a book, or a set of procedures. It is, at its core, a creative act. It is this action – what you do to attain a desired goal that this document is all about. Given that, this section of the *Tools for Changing the World* includes activities for you or your team to do.

"A revolution is not a dinner party, or writing an essay, or doing embroidery; it cannot be so refined, so leisurely and gentle, so temperate, kind, courteous, restrained and magnanimous."

— Mao Zedong, 1927

The design science planning process is a method by which individuals or small groups can solve complex real-world problems. It facilitates the development of alternative solutions to problems, and strategic designs and plans for implementing those solutions. It identifies what needs to be done, when it needs to be done, by whom, and in what sequence, as well as identify what resources are needed to implement the design. And it does this within the conceptual framework presented in the preceding section of this book.

Methodology: 1. The system of principles, procedures, and practices applied to a particular branch of knowledge; 2. a manner or means of procedure, especially a systematic and regular way of accomplishing a given task

The flow-diagrams on the first two pages of this section outline the design science process. It takes the design scientist from problem recognition through a systematic and comprehensive design process in which the goal or target (the Preferred State) that the designer is aiming for is clarified, made explicit, and used as the guiding force in developing the overall strategic design and plan that gets us to the Preferred State.

What should we focus on and where in that great buzzing confusion of the world will it be most efficient for us to apply our energy, intellect, time, and passion so that we have the most impact?

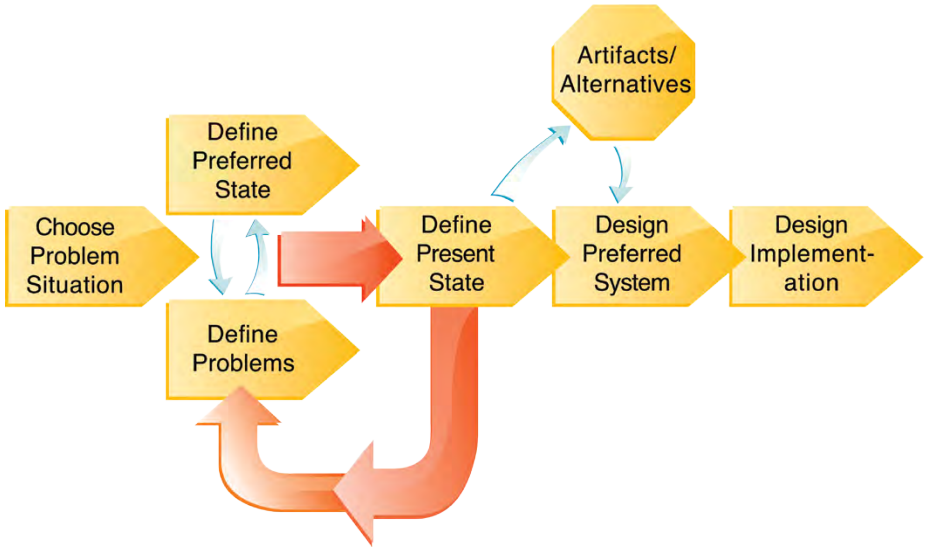


Figure 25. Overview of the design science planning methodology

And yet more specifically:

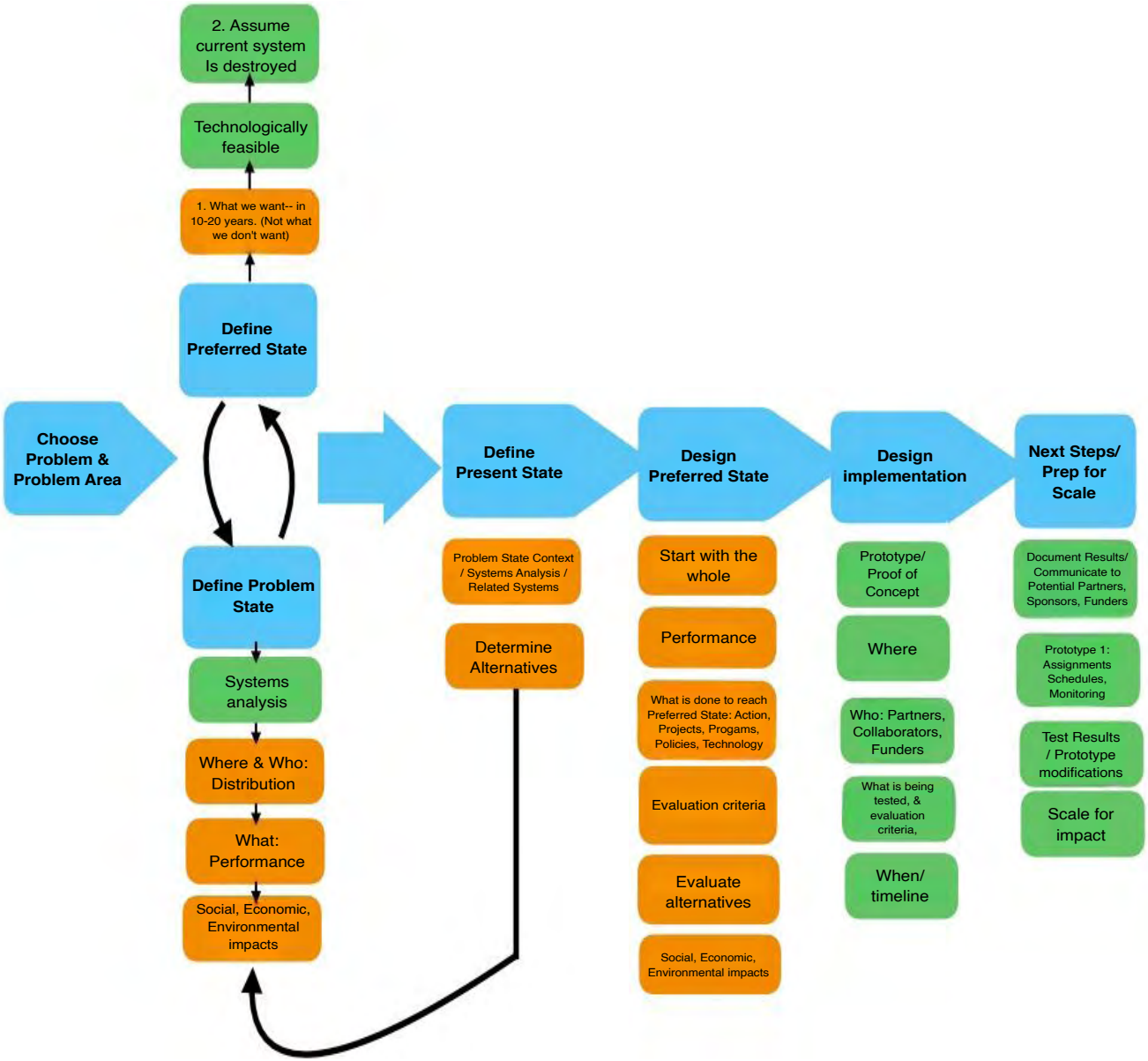
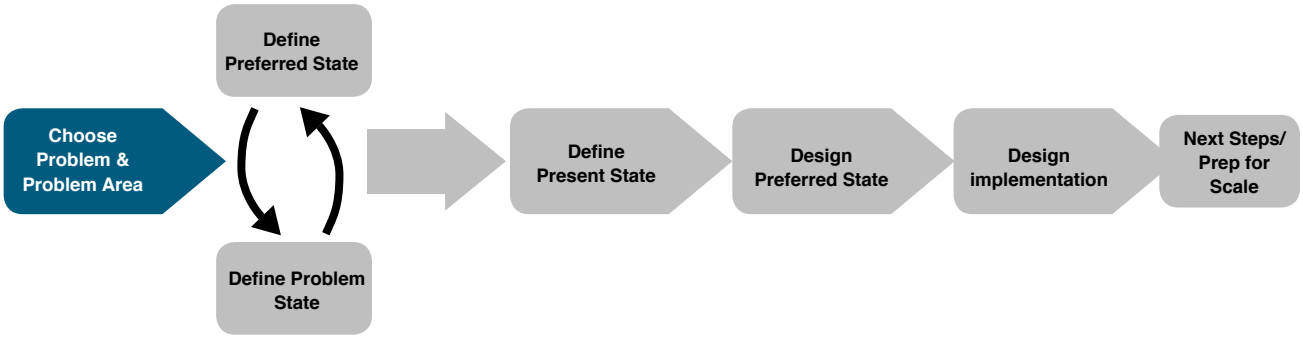


Figure 26. The Design Science "Preferred State Problem Solving Planning Process"



Recognizing the Problem Situation/ Choosing the Problem

> "It isn't that they can't see the solution. It is that they can't see the problem."
>
> — C. K. Chesterton

Moving from Problem to Problem Situation

The first step of the design science planning process is deciding what problems we as an individual or group will address. Here's the simplified process:

1. We start with our values, with what we see, and feel, as the problem we want to solve. 2. And then we back up.

This leads us to a more comprehensive picture—the situation in which the problem is embedded. Most problem situations will have local and global environmental, technological, economic, cultural, and political aspects or components.

If we started with our concern or outrage that there are hungry people in the poorer parts of the world—of "hunger" as the problem, and its symptoms (how we know the problem exists), as 800+ million people in the world without access to enough food, or the number of people in the world starving, malnourished, threatened by starvation, going to bed hungry, etc., then backing up we see a bigger picture that can lead to causes of the symptoms we first noticed. Such as, in the hunger example, the problem involves the environment, including climate change, plus food production, distribution, waste, affordability, access to land, energy, water, technology, as well as social justice, gender equity, national policies, subsidies, incentives, and the global economy.

It is likely that what we think of as a "problem" are likely symptoms of a set of interacting threats and opportunities. This general "problem situation" can be referred to as the "mess" for short.

What does hunger in a specific region of the world fit into? What is the larger system or mess of which it is a part? We need to ask, what causes the symptoms that we think of as the problem?

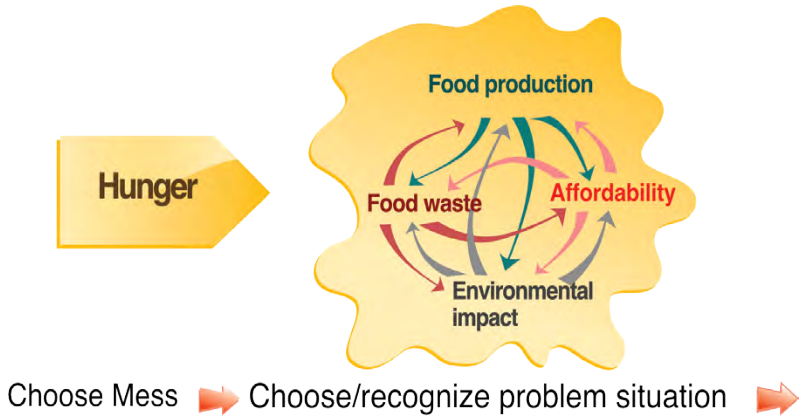


Figure 27. Step one of the design science planning process: deciding what problem to focus on. What we think of as a "problem", like "hunger", is usually part of a larger set of interacting threats and opportunities or what may be called the problem situation or "mess".

Deciding what problems we will pursue is not as easy as it appears. It is also critical to the success of our work. The values, perspective, interests, resources, and talents of the designers undertaking this initiative will help determine both what the problem or mess is (the design focus or project)—and its outcomes. Determining and clarifying these values is essential. Answering the questions above will help in this process.

Mess contains the problem
Start with the problem situation— the "mess"— that the problem with which you are concerned is embedded within.
Look for the bigger picture.

Determining the problem #2

Part of the design process is working in a Design Team. Another part, after we have developed a solution to the problem (or getting to the Preferred State as the next sections will clarify), we most often need to expand our team by finding partners, sponsors, and/or collaborators that can help in implementing our strategic design and strategy.

The same general principle can also apply to picking our problem area focus. For example, the UN's Sustainable Development Goals are a list of 17 global problems that are of critical importance to making the world work for all. (See "Figure 2" on page 8). A lot of work has gone into the definitions of what these problems are, the statistical

descriptions of them, and other valuable information on the state of the world. This body of research is available online and can be of great help in the entire design science process. Appendices 2 and 3 have links to these resources.

Moving from Mess to Vision

We don't start out with problems all neatly prearranged for us to solve. The real world is not arranged like a math textbook. Usually, a problem situation or "mess" confronts us. But there is more. *Good problem solving does not start off with assuming we know what the problem or mess is.*

If we accept given prepackaged problems, we will be starting out with hidden, predetermined assumptions that can interfere with developing a creative response to the real problems causing the situation we are seeking to fix.

Once we define what the "problem" and its enveloping "mess" is, we have bought into a lot of self-limiting and hidden assumptions that curtail the options we have. We need to take care to define the problem/mess, not its symptoms, from a context and perspective that will provide us with the options needed to reach the Preferred State.

Recognizing only the apparent issue is part of the problem itself. If we select a problem without considering its context, our thinking becomes restricted, and we may miss potential solutions. To simplify the design process, one approach is to reconsider the "problem" by determining the ideal outcome for the situation it is part of. Imagine how the situation should ideally be, based on our values. What should the system achieve? This activity helps shift our focus from the specifics of the "problem" (symptoms of systemic issues) to the overall behaviors of the entire system we want to alter, aligning them with the envisioned Preferred State.

Considerations in Choosing the Problem

> "The only way of understanding a system is to understand the system it fits into."
>
> — Howard Odum

A general "problem situation"—not a specific problem— is chosen. The context for a specific problem is the problem situation. Every problem has a larger system of which it is a part. The "problem situation" is what your values tell you are important (hungry people, illiteracy, lack of access to health care, environmental destruction, etc.). From this general area of concern we both zoom-in to a specific problem we want to address, and zoom-back to take a bigger picture view of the problem area. For example, we zoom-in to identify malnutrition in rural villages, and we zoom-out to the global food, economic, technological, and ecological systems.

There are many approaches a design science planning team can take in choosing a problem situation. The following are four that have been used by groups at previous design science planning sessions.

1. Focus on a specific *functional* area of *human life-support*, such as food or shelter, and develop a strategy for meeting these needs at a chosen geographical scale (from global to individual dwelling) or at a trans-boundary level.
2. Choose a particular *geographical area*, such as a neighborhood, region, or nation, and develop a strategy for that defined region which includes one or more of the functional life-support areas.
3. Take one of the *trans-boundary* categories (such as climate change, urban areas or slums) and develop a solution to a basic human need in that category for a specific part of the world.
4. Choose a problem that has been identified by others that resonates with your values, for example in the annual assessment of global risks,[64] in the progress report on the UN Sustainable Development Goals,[65] or in the analysis by The Fund for Peace[66] or other credible international organizations.

Table 7. What are the dimensions of the problem we should address?

Examples of areas of human needs	Examples of geographic scales for focus	Examples of Trans-boundary levels of focus
Food Water Shelter Sanitation Health Care Education Energy Transportation Communications Materials Recreation Logistics Environment	Individual Dwelling unit Neighborhood/Community City State region State National region Nation Global region Global	Climatic region /bio-region/ water-shed Economic status Geographical and Economic status (urban slums, rural poverty) Level of technology use Religion or other cultural dynamic Market access

64 Emilio Granados Franco et al., *The Global Risks Report 2022* (Geneva: World Economic Forum, 2022), https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf.

65 Our World in Data Team, "SDG Tracker: Measuring Progress towards the Sustainable Development Goals," *Our World in Data*, 2023, https://ourworldindata.org/sdgs.

66 The Fund for Peace, "Measuring Fragility: Risk and Vulnerability in 179 Countries.," 2023, https://fragilestatesindex.org.

If we choose to work with an area of human needs, we need to define the geographic scale we want to focus on. If we are planning the development of a specific geographic region, then we need to decide which functional areas, at that level, on which we want to work.

Functional definitions

A next step is to develop working definitions of the functional area or areas with which we will be dealing. A *functional definition* describes what the system you are considering *does*— what its function is within the larger system of which it is a part. For example, each part of humanity's external metabolic system (see "Technology as a living system" on page 35) plays an essential role in the operation of that system just as each part of our internal metabolic system plays an essential role in the operations of our bodies (such as circulating blood/nutrients or transporting essential goods). This role is a specific function that needs to be performed for the rest of the system to work properly—to maintain itself and to continue to thrive and evolve.

For example, if we are focusing on energy supply for Africa:

What is the definition of energy? "The capacity to do work."

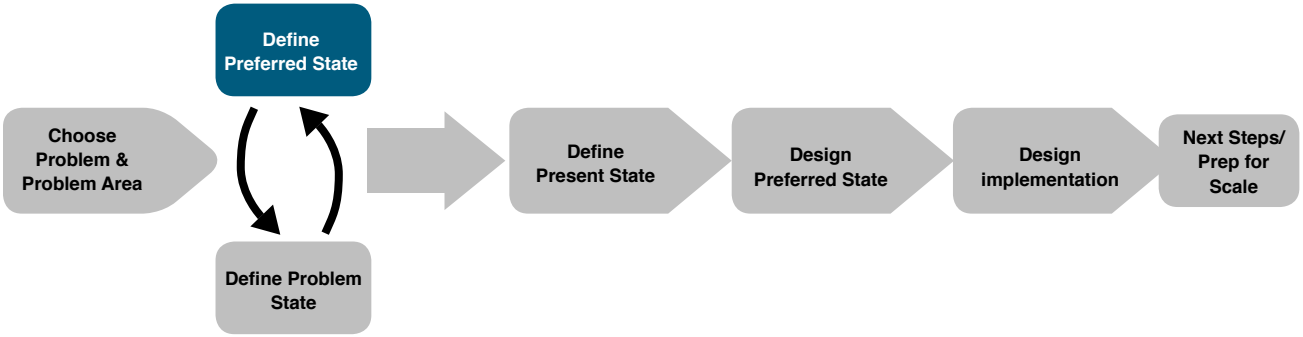
What role does it perform in the system for which we are seeking to develop a solution? In supplying energy to rural areas of Africa, energy is used to power food production, water pumping, vehicles, lighting, and economic activities.

Summary

The first step in the Design Science methodology is choosing the problem area to focus on. The choice of the problem area is based on a combination of our values, knowledge and preliminary research. Our understanding of the problem will increase as we proceed through the methodology, considering not just the symptoms but its root causes— as well as where we see the problem situation should be— our Preferred State.

Activities for you or your team to do —Questions

1. What problem or mess have you chosen to focus on?
2. What are the symptoms?
3. What causes those symptoms?
4. What are the dimensions of the problem?
5. What geographic area of the world are you most concerned about?
6. How is this problem related to everything else?



Envisioning the Preferred State

Defining the goal

> "The inability to envision a positive future is, in itself, a threat to survival."
>
> — Russell Ackoff

> "A pile of rocks ceases to be simply rock when somebody contemplates it with the idea of a cathedral in mind."
>
> — Antoine de St. Exupery

The chart below describes the next step of the design science process. Having chosen a general problem situation and a more specific problem within that area, we now determine its *Preferred State*. The Preferred State is sometimes referred to as an "Idealized Design" and relates to our goals and visions for a better world. We do this determination by listing the qualities of a state that is preferable to the problem situation.

A Preferred State is the design of the system according to our values, vision, and perspective. Political and economic constraints are removed. Technology, operational viability, and environmental health are the constraints governing the design of the Preferred State—which needs to use present day technology and known resources. No magic wands.

The Preferred State describes what we want, not what we think is probable or will be permitted. It is preference, not prediction. It is not what we think will or can happen. Rather, it is a bold statement of what we want to happen— what we wish the world looked like. It is often revolutionary and transformative, not evolutionary, or incremental. The Preferred State is in stark contrast to what politicians, bureaucrats, and the current economy will allow or think is practicable, expedient, or currently affordable. They are preoccupied with the problem, the "disease". Just as medicine's first concern was with pathology and then progressed to figuring out what optimal health

is all about, so too design science focuses primarily on the optimal health of the system that the problem or "disease" is contained within.

The Preferred State is our definition of health, not pathology. It is our vision of what is possible, made real— in record time, sparing no expense, to universal accord (meaning no opposition).

The Preferred State asks us to answer:

- If the current system related to _____ (*insert the problem situation you have chosen*) disappeared overnight, what would we want to replace it?
- What is the ideal or preferred state of the problem situation?
- What would the world look like with the problem solved? / What will the impacts be of a world where the problem situation is no longer?
- What are the qualities of the Preferred State? What would it do?"

> "Our ability to solve problems is limited by our conception of what is feasible."
>
> — Russell L. Ackoff

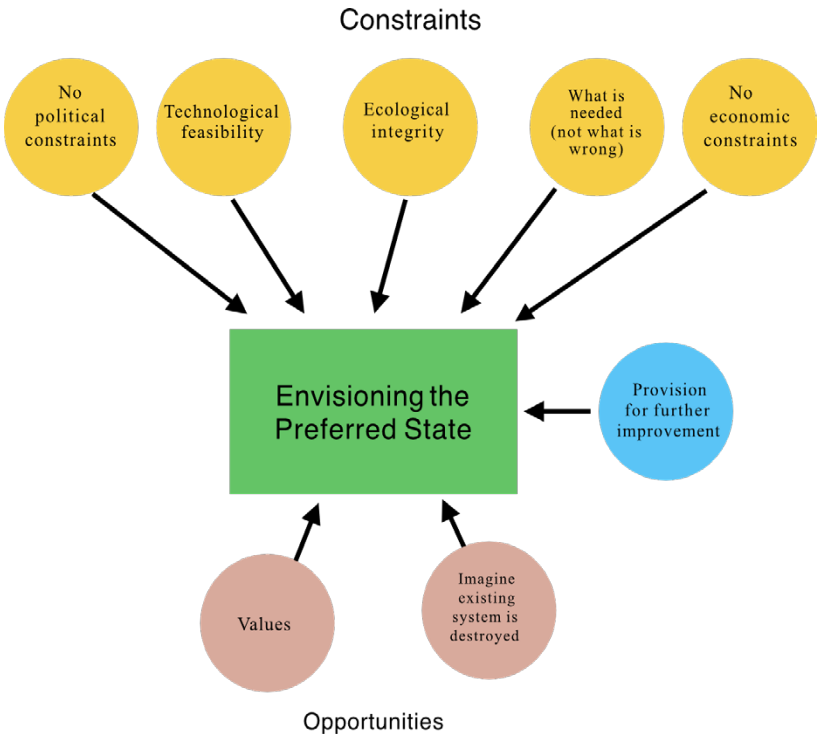


Figure 28. The preferred state: key constraints and opportunities

Another way of looking at the Preferred State is that it is an aspirational future. It is what we want or aspire to, not what we are afraid of. It is not a "needs assessments" but goal clarification. As such, it is a powerful tool for bringing about and managing change. What it is *not*, is wishful thinking. It is necessary for bringing about change. Yes, it is, by intention, visionary. But vision is powerful. Vision drives action, and money follows vision.

There are many tools for trying to guess or predict the future, but the key tools for creating the future are aspirations and the development of a technologically possible Preferred State. With a clearly defined Preferred State comes a shared vision, core values, appropriate options, and a set of decision-making criteria that guide the entire design science process.

As depicted in Figure 28, part of the process of developing the Preferred State is to suspend all constraints— including economic and political— except for those of technological feasibility, ecological integrity, and our values.

In doing that, it is often helpful to imagine that the current system is completely destroyed. Ackoff sees this assumption as critically important because referring to the existing entity restrains designers from thinking about what they really want. Their minds tend to get caught up in the constraints inherent in the current entity and its environment.[67] Elements of the current system may be included where they are deemed of value, but only where they're wanted, and not just because they currently exist.

In this exploration, we ask: How would we meet the need that the current problem area seeks to meet if there were no infrastructure in place? If we were starting from scratch, and had to meet the need for food, shelter, education, healthcare, etc.— whatever the problem area you are focused on— seeks to deliver.

Defining the Preferred State forces us to make explicit what we want and where we want to go. This step involves developing a working hypothesis which we will test and document as we develop a complete strategy. For example, if our Preferred State includes providing adequate nutrition for every human on Earth, the plan we develop then becomes an experiment to test if the goal is possible and how it might be brought about.

Frames of reference

Another way of viewing the Preferred State is to see it as a frame of reference to the present situation. This provides a perspective from which to view the difference between what is happening and what should be happening. A physician diagnoses a patient based on knowledge of a "healthy" or Preferred State functioning of the body. Problems can be better understood by referencing them against as clear as possible a notion of how the system should be working. Though humans rarely define a Preferred State for society and use this as a tool for understanding and resolving our problems, it is essential in order to plan for the future.

67 Ackoff, Magidson, and Addison, *Idealized Design: Creating an Organization's Future*, 41.

Brainstorming

Defining a Preferred State can be a simple brainstorming game. Extensive research and technical analysis are unnecessary for determining what we want. Everyone is an expert on what should be. Everyone has an equal right to contribute and help form the goals in the design science planning process.

Brainstorming is a group method for generating ideas. This helps to produce many perspectives on what should be included in the preferred state.

Start this activity by determining a period of time the activity will last. Ten to fifteen minutes is usually sufficient.

Then ask the group to offer different ideas or views of what should be in the preferred state. During the brainstorming session, there is no criticism of ideas proposed, or analysis. Have a member of the group list the ideas on a whiteboard or flipchart as they are suggested without modifications or arranging. The important role of brainstorming is that it allows a diverse and wide-ranging set of responses to be generated without judgment. Brainstorming is not analytic and imposes no constraints on the listing of possible ideas.

Brainstorming is likely to produce better results when it is done by a diverse design team, as discussed above under identifying the problem.

Refining the Preferred State

After the brainstorming session, the preferred state can be refined, consolidating ideas that are similar, and organizing the items into categories, such as elements of the preferred state related to performance, scope, and environment. The preferred state will continue to be refined throughout the design science planning process, reflecting growing understanding of needs, opportunities, and challenges.

Our descriptions of the Preferred State will change and evolve as we explore new ways of seeing problems and developing options for reaching the Preferred State. As our personal values, vision or perspective change, our Preferred State descriptions can change. It is very useful to repeat this Preferred State formulation step over again (and again) in order to clarify the common objectives of the planning team. Such an exercise functions as a reality check on the design science process.

For example, Table 8 illustrates a Preferred State for the global food situation developed by a design science group focusing on that human need area. This Preferred State was developed by a team over weeks of work and incorporated all that they learned over that time. Their first draft began as four or five characteristics of an ideal food system and grew as their research led them to new nuances of the problem situation. The development of the Preferred State is an example of the value of a diverse design team and their creative interactions.

Table 8. Example of a Preferred State for the global food situation

Criterion	Feature
Availability	An abundance of nutritious, delicious, culturally appropriate, and affordable supply of food for all of humanity's healthful thriving and evolution is available on a regenerative basis. The fear of an inadequate food supply is vanquished. Planning and management of the global and local systems are as comprehensive and anticipatory as possible to insure a guaranteed regenerative supply of food for everyone.
Diversity	The global food system allows for maximum individual flexibility in food types to encourage as much cultural and culinary diversity as possible. There is an optimum diversity of food crops and a diversity of different strains within each crop. There is an overall genetic bank increase.
Safety	The food system, as well as the food, is safe. For example, farm workers as well as food should not be exposed to dangerous chemicals.
Human rights	Food is a birthright, not an economic weapon of exploitation. There is no coerced human labor involved in the food system.
Environment	The global food system is regenerative; that is, it is not based on resources which are rapidly being depleted such as fossil fuels and it is not based on short-sighted practices such as poor soil management. The food system leaves the food system's environmental support systems stronger, healthier after harvest than before. The food system has the least possible negative environmental impacts and the most possible positive environmental impacts as possible, such as the build-up of poor soils into rich soils.
Resiliency	There is a minimal dependence on adverse fluctuations in natural cycles. There is a built-in flexibility in the food system; there is a back-up storage system to ensure the maximum amount of nutritionally sound food to maximize the number of forward days for all of humanity. The fear of an inadequate food supply is vanquished. Planning and management of the global and local systems are as comprehensive and anticipatory as possible to insure a guaranteed regenerative supply of food for everyone.
Efficiency	The global food system operates at maximum efficiency—minimizing the need for energy, materials, land, and human time use in all stages of the food system. There is a minimum of waste food. The amount of food lost to waste is continuingly reduced.
Information	The global food system is comprehensively monitored and feedback obtained for quality and quantity control. Access to all accurate food information is readily available to everyone. There is a maximum amount of research and development related to improving the food system.

Envisioning the Preferred State with AI assistance

AI may help us to refine our description of the Preferred State.

After our team envisions our Preferred State for the problem area by answering the questions described above, we can use our AI "team member" as a way of helping to flesh out the Preferred State. The additional perspective of AI can be of assistance to our team.

The following prompts are examples of the types of queries that that may be productive:

- If all the problems associated with the global _____ (*insert your problem area*) were eliminated, what would the global_____ system look like?
- What will the world look like if there is no _____(e.g., hunger)?
- What would the impacts be if the global _____ (e.g., hunger or food system) problems were eliminated?

> *"When you talk about the problems, you tend to disempower people. You tend to make people feel that there is nothing they can do, that they are doomed, that there is no hope."*
>
> — Wangari Maathai

Summary

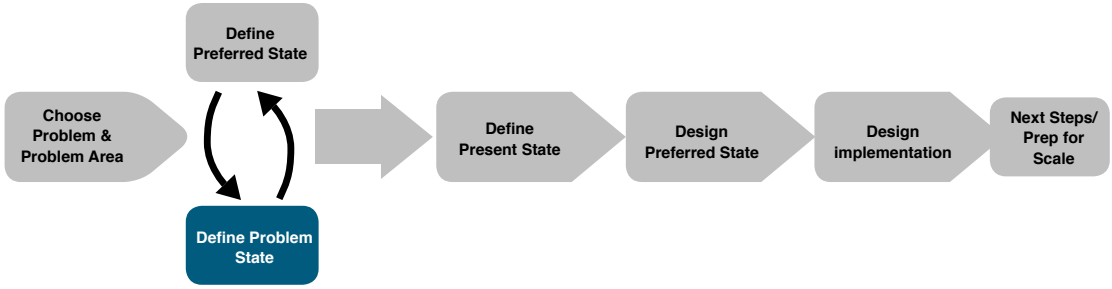
When we talk about the Preferred State, we empower people with a vision of what is possible– a basis for hope and determining what they can do to make it real. Starting with a Preferred State builds consensus, agreement and inspires motivation and action. It involves everyone, as everyone is an expert on what they want.

Developing a Preferred or ideal state provides:

- A positive, visionary goal that builds consensus.
- A focus on what is needed, not what is deemed feasible, expedient, or most profitable by the status quo, politics, and current economics.
- An organizational framework for thinking about the future and defining the problem situation and alternatives.
- A definition of a healthy system; a definition of success; our goal. As such, it organizes the path to reach it.
- A set of decision-making criteria for deciding which alternatives are best.
- An "outside the box", big picture, expansive, larger system's view of the problem situation and the number of possible intervention points and options.
- The behavior of the whole system, and many of its parts— by which the discovery of the remaining parts can be discovered.
- A way of developing solutions to a problem that go beyond "problem solving"— that builds capacity and grows wealth, not just reduces poverty.
- A Preferred State supplies us with a first draft of our "Problem State" (see below).

Activities for you or your team to do —Questions

1. What does your preferred state say about resource usage?
2. Does your preferred state address all of humanity or some subset?
3. Describe how your preferred state draws from and enhances or impacts the natural environment?
4. Explain how your preferred state considers all stages of the system it is addressing, for example including production, transportation and distribution, usage, and post-usage.
5. Describe how your preferred system contributes to equity and human rights.
6. Describe how your preferred system respects different cultural and ethical values of different communities.
7. What education and information systems are part of your preferred system that empower making informed and responsible choices?
8. How does your preferred state interact or relate to other systems?



Defining the Problem State

> *"The formulation of the problem is often more essential than its solution."*
>
> — Albert Einstein

Simultaneously with the development of the Preferred State, we create a first draft of the Problem State. In this case, the initial, first draft Problem State is the inverse of the Preferred State.

For example, if the Preferred State is "the provision of abundant supplies of clean and affordable energy to all," some of the components of a Problem State embedded within this Preferred State are:

- Inadequate supplies of energy, not enough for all
- Current supplies of energy are not clean; they are derived from CO_2-intensive fossil fuels
- Current supplies of energy are not affordable to many.

Recognizing and defining problems is a difficult and critical task. We are familiar with news reports and analyses of current events in the media. Usually what we call problems are really only symptoms

of problems. *Symptoms are the visible effects of a problem, while the problems themselves are usually related to the functional or structural characteristics of a system.* Distinguishing between symptoms and problems is important in making more accurate definitions of the problems we want to resolve— and in developing solutions that bring about the changes we want. Treating symptoms doesn't solve problems. At best, it makes us feel like we are doing something, and comes up with a solution which is destined to fail slowly, and most often, results in another, equally or more serious problem.

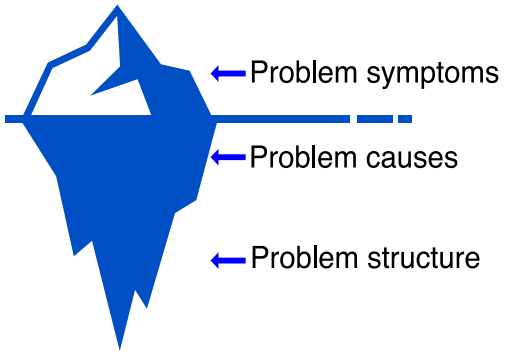


Figure 29. Like an iceberg, there is typically much more involved than consideration of the visible symptoms alone would suggest.

Lenses and yardsticks

The way we describe the problem depends on the lenses we use to see and the yardsticks we use to measure. The Problem State is what is not working in the system we want to change. Collaborative problem solving and strategic design and planning bring multiple perspectives to the recognition and definition of a problem. As more people come to grips with the complexity of a problem, the richness of its description increases. And, as this happens, more alternatives emerge that will get us to the Preferred State.

Everyone brings his or her own frames of reference to the design science planning process. These perspectives are based on different political, economic, cultural, psychological, organizational, and religious values and experiences. It is important to understand when and how we use these perspectives and to see the degree to which our own cultural values influence the way we define problems. However useful these frames of reference may be in organizing our ideas of the problem, we must take care to see that they do not inhibit, limit, or predetermine our understanding of the problem.

Start with the larger system

> "If you can't solve a problem, enlarge it."
>
> — Dwight Eisenhower

It is important to remember that, at whatever level your focus, design science "problem solving" should move from the general to the specific— from the "whole" to the parts— from the generalized principle to the special case. In design science,

problem/mess recognition starts at the global level and works in towards the local level, thus ensuring that all subsequent strategies or artifacts developed locally are compatible with global potentials and restraints.

Expanding the scope of the problem, so it is not just a village or even the country that the village is located within, enlarges the number of options and the way we look at the problem. In the South Sudan village example, enlarging the problem from a lack of food in a poor African country to the global food, ecological, economic, and technological systems will allow us to see options that were not present in the smaller, more local system. From this perspective, solving the problem often becomes a question of what we can introduce from outside the local problem system that will bring about the changes we are seeking.

One way of looking at the hunger problem in, for example, the South Sudan, is to see it in the context of larger and interlocking geographical, geopolitical, cultural, ideological, and ecological systems. Whether it is the bioregion, a village or nation, every problem we address is part of larger systems.

We always start with the larger system. (And remember, until we get to the Universe, there is always a larger system.) If we defined our problem as the lack of food in a village in South Sudan, we might find ourselves limited to the options available in the local food system. We would likely see a "solution" as way of expanding the local food supply from local resources. And if this were to happen, we *might* have a solution that helped the problem situation in the short term, but we would miss over 50 to 90% of the available possible long-term and regenerative solutions to the problem. *Thinking "outside the box" is thinking outside the system the problem is within.*

Dimensions of the Problem

In developing the description of the problem state, we need to consider multiple dimensions, or ways of looking at and defining the problem situation. These will include, for example:

- **Impact:** In what way are people impacted by the problem? How many people are impacted? (And who might be impacted positively by the status quo setup? Who is benefiting from the current system?)
- **Geographic distribution:** Where are the people who are impacted? Where are the resources and technology that are needed to reach the Preferred State?
- **Demographic distribution:** When considering values that describe or affect people it is important not to focus only on the average value but also the distribution. Average values may obscure important distinctions. For example, data on average income per person by country do not capture that there is poverty within countries with high average income and that there are wealthy individuals within countries with low average income.
- **Performance:** What are the deficiencies or production shortages of the current problem situation? What are the limits of the problem

situation in terms of its capacity to produce life-support goods and services?

- **Environmental impacts:** What are the environmental impacts of the problem, and what are those impacts on people?
- **Maintenance and change:** How is the problem situation changing? Is it getting worse, slowly better? How is the problem situation regulated, staffed, managed, maintained?

An example of a problem state description is presented on Table 9.

Table 9. An example of a problem state for the global energy system

Criterion	Feature
Availability	*Not enough* energy available for 100% of humanity's life-support, e.g., 1 billion people without access to electricity; "blackouts," "brownouts" and fuel rationing; little or no industrial energy available to construct and further develop life-support systems.
Diversity	*Low diversity and redundancy* of energy sources and systems; e.g., most of our "eggs" are in one basket— fossil fuel.
Safety	*Unsafe* use of human physical labor (coal mining, oil refining, etc.).
Human rights	*Inequitable distribution* of energy; for example, the United States, with less than 5% of the world's population, consumes over 20% of the world's energy.
Environment	*Negative environmental impact* of energy production and use in the global energy system, e.g. resource depletion, waste, pollution of air, water and land by unwanted chemicals, heat and noise; and disruption of ecological cycles through strip mining, waste and pollution; in short, an environment whose capacity to provide what we are demanding of it, and to absorb what we are injecting into it, is rapidly being overwhelmed.
Resiliency	*Over-dependence* on limited energy resources, such as fossil and nuclear fuels. *Centralized and one-way energy systems;* i.e., energy flows from monopolistic utilities and corporations to individual consumers, without the inverse option.
Efficiency	*Low efficiency* of energy conversion, such as appliances that waste electricity, cars that get low mileage per gallon of fuel, materials that require a lot of energy used in place of low-energy-costing materials, uninsulated structures, etc. Present-day energy converters average 4–5% over-all thermal and mechanical efficiency. For every 100 barrels of oil produced, approximately 95, as far as doing productive work, go down the drain. An overall efficiency of at least 12-20% is feasible with present-day design and engineering know-how.

Defining the Problem State with AI assistance

AI can help to define and clarify the Problem State. As discussed above in the section on AI ("AI as a tool for defining the problem and developing solutions" on page 71), a key to effective use of AI relates to the prompts you use. Some possible prompts for a food/hunger related problem might include:

- How many people are hungry in the world? What are the sources of the information provided.
- If there are multiple answers choose the ones that have the most recent source publication dates and are the most relevant to your interests. If you don't get the information you need, ask different questions, such as the following:
- How many people are malnourished, starving, stunted, in danger of food shortages, etc. (plus sources for each question asked).
- Give me an overview of the world food (or other) problem based on latest UN reports.
- What is the most serious problem related to world hunger?
- What are the major parts of the global food system?

Similar types of questions could be used for other problems.

Consider adding additional detail to your prompts. For example, you might add: Write for a well-informed audience. Use an academic tone. Make it concise. Summarize at the end and provide references.

Remember that most AI systems have a memory. They keep track of what you wrote. You can use/build on this memory in your revisions to your prompts.

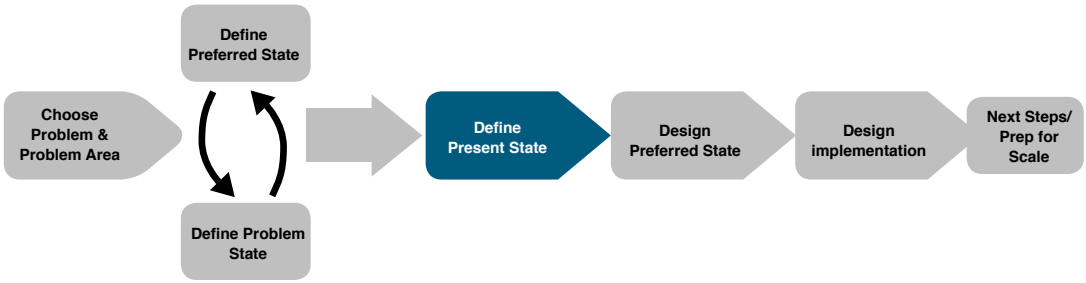
Summary

Developing a comprehensive Problem State provides:

- A whole system, big picture view and analysis of the problem situation we are working on, not just surface symptoms.
- The discovery of unknown, often surprising, factors that can change our understanding of the problem situation, and our solution options.
- A set of possible intervention points for our solution to gain traction and achieve the Preferred State.
- The discovery of "trim tab" intervention points where the most positive results can happen with the least amount of effort, resources, and costs.
- A discovery of options— technologies, policies, and actions that can be developed, implemented, scaled that will reach the Preferred State.
- The discovery of additional factors that can or need to be added to our Preferred State.
- An additional organizational framework for thinking about and explaining to others the present, the desired future (Preferred State), and options for getting there.
- The definition of an unhealthy, diseased system, its impacts and future prognosis.

Activities for you or your team to do — Questions

1. What are the symptoms of the problem state? How are they distributed across geography and populations?
2. What are the root causes of the problems?
3. How does your problem state relate to other social or environmental issues?
4. What are the gaps and barriers in the current system?
5. Are there other aspects of your preferred system that aren't being met by existing systems?



Defining the Present State

"We are continually faced with great opportunities which are brilliantly disguised as unsolvable problems."

— Margaret Mead

"There is no such thing as a social, political or economic problem. There are just problems with social, economic and technological components."

— Russell Ackoff

Context

The Problem State is a *part* of the Present State. We need to define and understand the larger system, the Present State, to discover the causes of the problem situation and the alternatives that are available for achieving the Preferred State.

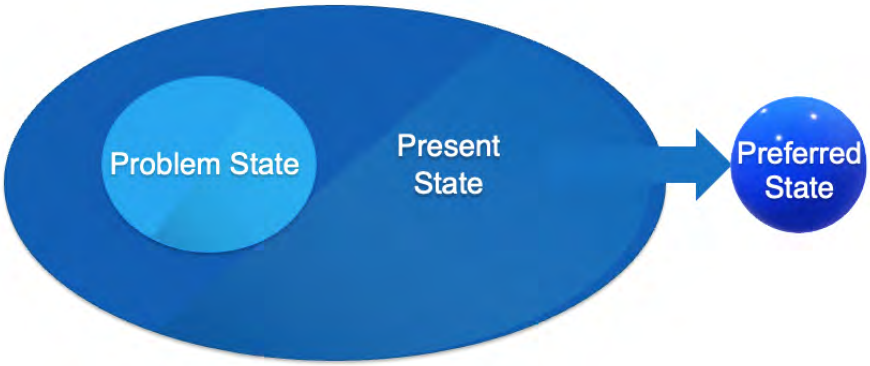


Figure 30. The Present State is the context of the Problem State. And, the problem state is a part of the Present State.

The Problem State and the alternatives to the Problem Situation are contained within the Present State—and what our team can invent or develop from the present-day, or soon-to-be-present, technology, policies, and actions.

How can we describe the Present State? How is the present system operating? What do we need to know? In describing the Present State, we attempt to gain a comprehensive picture— a many-faceted analysis of the present situation. The purpose of this step is to clarify critical factors of the problem situation that will enable us to discover the most effective alternatives for achieving the Preferred State.

Part of the conceptual environment of the Present State is knowing what the "business as usual" future will be. This is the linear extension of current trends into the future. In this future, the future looks like today, only bigger. In many cases, extrapolating present trends into the future breaks the system. For example, projecting present carbon-intensive energy use and growth into the future overwhelms the environment's ability to absorb the waste products of such growth— and without any change in direction, changes our global climate such that life as we know it on Earth ends.

> "If we don't change our direction, we will end up where we are heading."
>
> — Ancient Chinese proverb

Alternatives

Describing the Present State is not just about understanding the context of the Problem State, it is also about understanding what technologies and resources are available, and where things are working well already. Inventorying existing alternatives and *developing new ones* is a critical need of society and the task of the design scientist.

It is important that the list of alternatives be comprehensive so that the range of choices is as inclusive as possible. To make as informed a decision as possible we need to be able to compare each alternative to determine which is the best for reaching the Preferred State as quickly as possible for the greatest number of people using the fewest resources.

We need to have information about each alternative including: how it works, its impacts, the resources it needs, how readily available it is, and the particular situations to which it is best suited.

Here are some reasons why we need to identify as many alternatives as possible:

- The technological and geographical availability of any alternatives reflects the degree of our freedom of choices. No freedom of choice can exist where there are no alternatives. The more alternatives a system has, the more viable that system will be.
- Inventorying existing alternatives helps us see what new alternatives are needed, and which new ones need to be developed. This is a critical need of society and the task of the design scientist.
- Seeing all the available alternatives can suggest new ones, or combinations of existing ones.
- A limited availability of alternatives can threaten the survival of a system. If an electrical circuit has only one pathway for electricity to flow and the wire is broken, the system ceases to function. In an urban electrical grid, as in your brain, there is redundancy. This means that if one cable or neuronal circuit breaks or becomes dysfunctional, there are other paths for electricity or signals to flow so that the whole system does not shut down.
- Living systems are able to grow in a changing environment because they are incredibly complex, having many alternative pathways for achieving any one goal.
- The more alternatives we have the more flexible, comprehensive, effective, and efficient can be our designs for achieving the Preferred State.

EVALUATING ALTERNATIVES

Some of the questions we will want to consider in evaluating alternatives are shown on Table 10.

Table 10. Considerations for evaluating alternatives

About the alternative	The context	Development considerations	Operational considerations
What is it? What does it do? How does it do it? How is it used? How do we propose to use it?	What are its advantages/benefits? What are the positive impacts social, economic, and ecological?	What resources does it need? How efficient is it?	What environmental conditions does it need to operate in?
What are the inputs and outputs?	What are the disadvantages/ costs? What are the negative impacts social, economic, and ecological?	How much does it cost? How will its costs be covered? Who owns it after it is implemented? Can it be owned, maintained, operated by the people it impacts?	What resources does it need to operate?
Capability: What can it produce? At what scale?	What is needed to prove the option is viable— performs as it is supposed to, can be scaled so it has the impact we want, is cost-effective and affordable given the alternatives (including doing nothing)?	How long will it last? What is its life expectancy/ useful life? What happens when its usefulness is over? How will it be recycled?	What kinds of personnel are needed to maintain and run it?
What are its best uses or applications?		What is it made of? What could it be made of?	How is it managed, regulated, and changed?
Where does it come from? What is its history?		What and who is needed to build or install it?	Where can we test it?
		What kind of personnel are needed to install it?	

Decision making criteria

After all alternatives are discovered, the next step is to develop a set of evaluation criteria by which the alternatives can be assessed and the best ones determined—and, if possible, modified or combined for maximum synergetic impact. Table 11 shows example criteria for the global energy system.

Table 11. Example of evaluation criteria for an energy technology

Relationship to larger systems	Internal features	Deployment features
What is its capacity to meet energy needs? Who owns it? Are ownership, operation and employment available to all? Is it part of the circular economy? What are its environmental impacts?	Is it durable? Is it safe over all stages of its life-cycle? Is the energy produced stable and consistent? Does it use materials efficiently? Does it provide feedback on its O&M?	Can it be deployed quickly? Is it sensitive to cultural differences? Is it affordable (compared to the existing system and other alternatives)? Is it easily integrated into the existing system?

Gap analysis

Once we have the Preferred State —our goal— and the Problem State— where we are right now— we can measure the gap between the two.

The identification of the gap between the two helps make evident design opportunities, as well as a clearer understanding of the problem.

One way of describing the task, or challenge, of the design scientist is that it involves the development of designs that eliminate this gap. But before we can close or eliminate the gap, we first need to know what the gap is quantitively as that will shape our response, our designs.

The following are some of the dimensions that can be used in defining the gap:

- How big is the gap between where we are and where we want to be?
- Where is the gap? All over, or localized in specific places?
- How many people are impacted?
- What is the gap composed of? (Food, energy, water, health care, education, etc.?) What "material" will it take to close the gap?
- What is the nature of the gap? Is it technological, a knowledge gap, a skills gap, a communications gap, a political gap, or an environmental gap?
- What is the cost of the gap to the global and local economy? To the health and well-being of the people impacted.

Defining the Present State with AI assistance

Just as AI can help define the Problem State and the Preferred State, it can help to define and clarify the Present State. Some possible example prompts for a food/hunger related Present State might include:

- What are the major parts of the global food system (insert your chosen problem area)?
- What influences the state of the global food system?
- What is the gap between the food problem state and food preferred state? For this prompt you will need to insert the present state from the "Defining the problem" prompt and your vision of the preferred state.

Again, it may be helpful to add additional detail to your prompts, both initially and when you see the first response from the LLM.

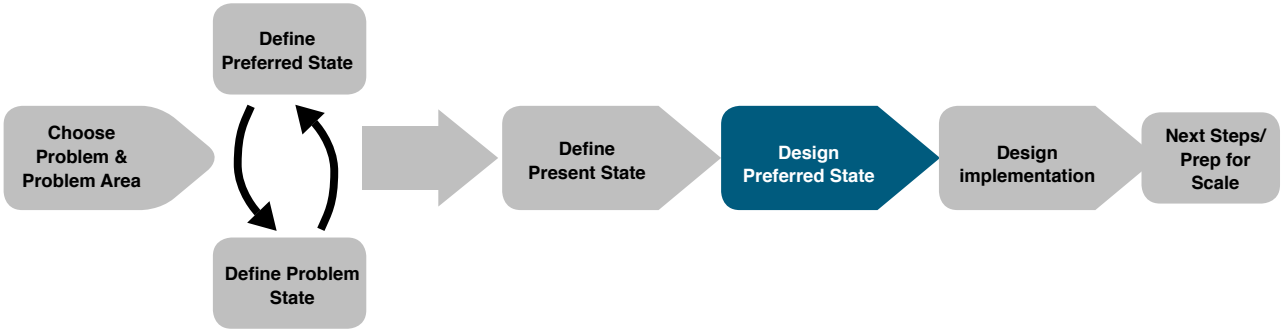
Summary

Developing a Comprehensive Present State provides:

- A description of how things currently are.
- It includes the Problem State and its context, and also aspects of today's systems that are working.
- It includes identifying alternatives that exist today that might help move us towards the Preferred State. These opportunities may be technologies, policies, programs, organizations, ways of organizing things, actions or other types of opportunities.
- It provides a way of seeing what alternatives or options do not yet exist, but which we can bring about through the combination of existing technologies.
- It includes determination of the gap between the Present and Preferred States, and provides a way to determine at what scale our solution needs to be implemented.

Activities for you or your team to do —Questions

1. What are the components of the present state and how do they interact?
2. What proportion of your target audience is currently experiencing each aspect of your preferred state?
3. How are the positive and negative aspects of the current system distributed? Geographically? Socially? Is the current distribution fair?
4. What are the environmental and social impacts of the current system, and how do they affect natural resources, biodiversity, climate and human well-being?
5. What are the existing policies and interventions that aim to improve your preferred state system, and how effective and equitable are they?
6. What are the drivers or enablers of change?
7. What resources are available to understand the current state of your system? Organizations, people, publications, databases?
8. What is missing in the current understanding of the current state? In the availability of information, tools, or technology?



Designing the strategy for achieving the Preferred State

Solution and strategy development: What, how, who, where, when, cost, funding

> "To oppose something is to maintain it. You must go somewhere else; you must have another goal; then we walk a different road."
>
> — Ursula K. Le Guin

What does your solution or strategy for achieving the Preferred State look like? What does it do? How does it work? What are its parts? Who does it impact? Who is involved in implementing it? Where is it implemented? What does it cost? Who funds it? What are the results and impacts it has? What is the proof-of-concept—that verifies that our solution works as claimed?

The focus of our design is on achieving the Preferred State. The vision of the Preferred State, our understanding of the problem, its causes, underlying structure, and the larger system it fits into, plus the list of alternatives for achieving the Preferred State, makes it possible to develop an innovative and sustainable strategic design that builds the capacity of the whole system in such ways that the initial problem we started with dissolves. It is replaced by a new option that makes the existing system obsolete.

The solution, the strategy for achieving the Preferred State, starts with our vision of the Preferred State. It then details how it is achieved— what is done, how it works, its cost and (in the design for the *Implementation* of our strategic solution), where it will be tested and implemented. It is a detailed strategic

design and plan, or blueprint, for getting to our ideal system. It is a design that organizes the parts of our solution so that, when implemented, it achieves the Preferred State.

We design the strategy for achieving the Preferred State by:

- Using the values, goals and measurable targets expressed in the Preferred State,
- Considering the Present, Problem, and Preferred States as a whole, not just their individual components,
- Selecting the alternatives that achieve the Preferred State, that are in-tune with our values (and our Decision-Making Criteria),
- Designing an integration of the alternatives we have selected into a system that achieves the Preferred State, and
- Documenting the results of the above. The strategic design and implementation plan (see next section) needs to be put into a form that can be used to communicate with others that our plan has identified as potential partners for the crucial real-world *Implementation Stage* of our design.

Alternative Selection

Selecting the appropriate alternatives and integrating them into a solution that gets us to the Preferred State involves three steps:

1. Determine which alternatives in our alternatives inventory would be part of a system that achieves the Preferred State and meets the requirements or specifications of our evaluation criteria. If there is no single alternative, which combination of alternatives will achieve the Preferred State? And if no appropriate alternative exists, what needs to be 'invented' using present-day knowledge for achieving the Preferred State? Often this "missing ingredient" is the key to the synergetic power and impact of the design and strategy. We must always keep our eyes on the lookout for these often "outside-the-box" options. They could be just about anywhere. And bear in mind that they might not yet exist— that they need us to creatively recognize the new, the possible, to bring them out, to make them real.
2. Determine which of the alternatives are appropriate to our plan by matching the Preferred State needs and environmental, social, economic, and cultural conditions required by each to the existing areas we are focusing on. For example, for an energy strategy, a wind-powered generator would be appropriate in a mildly windy area while a small-river hydro power plant would be inappropriate in an area where there are no appropriate streams or rivers. *If it is apparent that there are few, if any, appropriate alternatives that would contribute to the resolution of the problem situation and achieving the Preferred State, we need to develop a set of performance characteristics for several new and ideal alternatives. These design specs can then be used for developing new alternatives and artifacts.*

3. Integrate the appropriate alternatives into a working system where all of the parts are functionally interconnected and coordinated—and the synergy of the whole is capable of achieving the Preferred State. This step usually involves experimenting with different combinations of alternatives until a workable and optimal solution is achieved.

Efficiently running systems can have parts that if tested separately would perform inefficiently. (This understanding is implicit in the definition of synergy: the behavior of a system unpredicted by the sum of its parts. Another way of looking at synergy: you are more than just the sum of your brain, heart, stomach, and other body parts.) The implications of this phenomena for solution design are that we need to remember that we are designing a 'whole system'—and it is the behavior and performance of *that* system on which we need to focus, not its parts.

> *"Integrative design optimizes an entire system as a whole, rather than its parts in isolation. Optimizing components in isolation tends to pessimize the whole system—and hence the bottom line. You can actually make a system less efficient while making each of its parts more efficient, simply by not properly linking up those components. If they're not designed to work with one another, they'll tend to work against one another. … [W]hole-system thinking reveals and exploits connections between parts."*
>
> — Paul Hawken,
> Amory Lovins and Hunter Lovins[68]

WHAT MAKES A COMPELLING DESIGN AND PLAN?

1. Our Preferred State is comprehensive, robust and compelling and our design is consistent with the Preferred State.
2. Our design uses present day technology.
3. Our design draws on known resources.
4. Our design and implementation are "affordable." The more affordable the better.
5. The more people who "win," the better. Winning for 100% of humanity is the standard, obvious, and best goal.
6. The more understandable our design, the better.
7. The more sustainable, equitable, regenerative, resilient, and the more people positively impacted, the better.
8. Risks are manageable and uncertainties have been addressed.
9. What else? (This question is at the end of every list. It is a reflection of our humility in face of complexity, the ever-changing world, and our abilities to learn new things.)

68 Paul Hawken, Amory Lovins, and Hunter Lovins, *Natural Capitalism: Creating the next Industrial Revolution* (New York, NY: Hatchette Book Group, 1999). .

Identifying the resources required to implement our strategy

Developing the design for achieving the preferred state will require resources, and these can be of numerous types:

Physical resources

- Physical resources – materials and energy. Are these from our 'capital', or from 'income' sources? Renewable or non-renewable?
- What technology, tools and artifacts will be needed to implement each phase of the strategic plan?
- Spatial— what kind of spatial needs does our solution require?

Human resources

- Human resources – workers and organizations
- Who will be the in-country/on-ground partners, hosts and sponsors/funders? What new organizations will be required? For example, there is a proposal in *Energy Earth and Everyone* to create a Global Energy Utility that would be charged with the responsibility for developing global energy sources and systems located in the global commons, or outside of any single nation's jurisdiction.
- Who will implement each stage of our strategic plan?
- How can these people and groups be mobilized?
- How can the various groups of people who will benefit or be impacted by our strategic design and plan support and participate in the implementation and refinement of the strategy, be a part of our strategy? This important step should be further developed at this point. Increasing the awareness and participation among those people who will be affected by the plan needs to be integrated into the entire process from beginning to end. For example, illustrating the benefits of alternatives to the present non-Preferred State system will increase receptivity to our design.

Financial/legal resources

- Financial resources–getting access to or developing the resources listed above.
- How much money will be required to implement the solution/strategy? How much will be needed when, and for each stage of the implementation?
- Who will invest the money? Who can we partner with that could invest the needed financial resources?
- What legal or administrative resources–programs, policies or laws— are needed to assist our strategy's implementation?

Financial resources and whole system costs/benefits

Present-day accounting practices have limitations, often leading to erroneous conclusions about the magnitude of the benefits associated with achieving our Preferred State. One of these is they typically do not account for the economic value of all the moral, environmental and other values and vision that went into the development of our Preferred State. As a result, certain costs and benefits are excluded. Current economics is biased towards making profits, not meeting the needs of all.These exclusions are termed "externalities". Externalities commonly excluded from the "business-as-usual" accounting framework include: long-term sustainability of our biological life-support systems, the services provided by these systems, the devasting impacts of climate change, loss of biodiversity, the meeting of basic human needs and rights of everyone in the world, the costs of illiteracy, sickness, premature death, sub-standard housing, poverty, unemployment, and injustice.

A second limitation common to conventional accounting is "split incentives" which occur when the person bearing the costs is not the one who benefits. For example, if a tenant pays the energy bill, the landlord may have little incentive or motivation to upgrade the energy efficiency of the building.

Yet another is "split impacts" which occur when the people or a segment of a society benefits from an investment and another segment of the society bears a significant cost. For example, when a coal-fired power plant or a waste incinerator is sited, those living in the vicinity or downwind of those plants have to bear the health costs caused by the mercury and other dangerous pollutants escaping from the smokestacks of the plants.

As our strategies move closer to being implemented, we have to find ways of ensuring that the economic analysis incorporates externalities, and that the system is designed in such a way that all parties are incented to 'do the right thing'.

Things that seem too expensive may only seem so because we haven't dealt with these limitations of the accounting system.

At some point in the design science process the real-world costs of our strategy run into the constraints of the so-called "real world" economy. This economy's underlying structure and decision-making criteria—the economic accounting system—dictates which alternatives are "economical" or the most advantageous for making money from an investment. It is critical to keep in mind that this accounting system does not value much of what is important to our strategy, such as the above mentioned litany of environmental and human costs and impacts on long-term sustainability of our biological life-support systems, the services provided by these systems, the devasting impacts of climate change, loss of biodiversity, the meeting of basic human needs and rights of everyone in the world, the costs of illiteracy, sickness, premature death, sub-standard housing, poverty, unemployment, and injustice— to name some of

the vital metrics commonly left out of present-day economic accounting.[69]

Current economic accounting often biases corporate investment towards making profits, not meeting basic human needs of all. A whole-systems accounting can address these limitations head on. It would include the costs of implementing our strategic design, including technology, materials, energy, space, and staffing. To make a more compelling case to potential funders, such a whole systems accounting would also include the costs of the strategy to the environment and well-being of people impacted by the strategy. It would include the costs of *not* implementing the strategy, by comparing it with the costs of doing nothing or more of the same. Ideally it would include the monetary benefits to the investors, PLUS the economic short- and *long- term* impacts on the local and global economy, health and well-being of all the people in the world and the environmental life-support systems.

When all the costs and benefits of such a whole-systems economic analysis are done it will become clear that our design science strategy is less costly than doing nothing, doing more of the same, or just making incremental improvements. And most importantly, such a whole-systems cost/benefits accounting will be a solid foundation for taking our strategy to the next levels.

Initiating a larger planning process

This stage is related to the preceding outputs of the design science process in two ways. As pointed out, reducing a design idea to an artifact may involve more resources and skills than the individual or team possess. The strategy needs to be communicated to those who have the necessary industrial and organizational resources and capabilities to implement the strategic design and plan. Part of the design science process is to identify who these individuals, groups, organizations, and corporations are.

The second way in which initiating a larger planning process relates to the other outputs is in furthering the implementation of the larger developmental strategy of which the artifact is only one part. In all planning it is crucial to involve the people who will benefit or be impacted by a particular plan. The purpose of a design science plan or strategy is primarily the testing of a hypothesis and the development of alternatives rather than planning for others. Once a new option or alternative has been developed it can then be widely disseminated and a larger planning process instituted.

In this later process, those who the strategy would affect can become involved in the process. To a degree, this will be similar to the effort that the individual design scientist or team has already gone through. The people who will be affected by the plan need to know, need to find out for themselves

69 And if these considerations are mentioned, it is often what is called "lip-service" or greenwashing. When it is not, we should acknowledge and encourage such actions in every way possible.

(and not be told by "experts"), just what are their collective goals and what are the limitations and possibilities in their specific situation. People should plan, not "be planned for" because one of the most beneficial aspects of planning is the educational process which takes place during the actual planning. Beyond this, for any complex development plan to succeed, it needs the full understanding and active participation of all the people involved in the plan.

As stated before, the ultimate goal of the design science process is to bring about constructive change. It is to allow everyone on Earth the option of being a "have" rather than a "have not." Sub-goals, or steps, along the way to this overall goal include the generation and testing of new options for humanity, the development of detailed strategies for the realization of new artifacts that are needed for a strategy, the initiation of a larger planning process, and the self-education of the design scientist.

Process Summary

When designing the system for achieving the Preferred State, consider the following factors:

1. How will the system operate and function? What will it *do* and what will it look like?
2. How will the system improve the lives and well-being of the people it impacts?
3. What impacts will it have— both intended and positive, and unintended and possibly negative?
4. How will the system be built, installed, managed, regulated, and funded? Who will do and be responsible for these actions?
5. What are the steps to realize the system? What needs to be done first?
6. How much will it cost to test, and then to implement at scale?
7. What are the whole system costs and benefits of implementing our design? How are those costs and benefits distributed?
8. How will the strategic design and plan be funded? Where will the funds come from to fund a test or proof-of-concept of the strategic design and implementation plan?
9. How will the system differ from the present system?
10. How will the system be monitored so that evaluation of its performance can be made? How can it be improved?
11. How will the system increase the personal freedoms and number of learning opportunities for people?
12. How will the system adapt to further technological innovations and social change?
13. How will the system be used by a wide range of cultural systems?
14. What are the risks and uncertainties? What could go wrong?
15. What needs to happen first? In the first year? In the first five years?

Explaining our strategy

The strategy for achieving the Preferred State can be described with many of the same tools we used to describe the Present State. This is important for communicating our strategy to potential collaborators, partners, funders, and the general public.

For example, we might develop an *Input/Output diagram* showing the flows of energy, materials, information, and people through the system. We will also want to diagram the *Components and Processes* of the different parts and processes of the system. *Scenarios* could be developed to show how such a system would contribute to the conservation of natural resources or increase the levels of adequate distribution of essential goods and services.

Following our original intentions, the design/plan should specify the level of aggregation (global, regional, community or single dwelling unit for example) that we chose to focus on, but it should also describe the interrelationships of similar functional systems at other levels of aggregation. For example, a community food system could be related to the regional and global food systems or vice versa. Showing how your strategic design could scale— be replicated *en masse*— is also important for showing the global impacts of your strategy.

Developing the Strategy for reaching the Preferred State with AI assistance

AI works well as a generator of ideas and options. It is good at volume. Not necessarily *good* ideas but lots of them—and buried within the many might be a good to very good idea, or one that will trigger a new idea in your mind, or some ideas that working together could be great combinations. The following are some prompt examples to start with:

- What are the alternatives for _____ (examples from food problem area: eliminating hunger in the world; increasing food production; increasing the amount of land being irrigated; reducing post-harvest food waste; making food affordable for everyone, etc.) Tip #1: Take one of the facets of our preferred state and insert it into the prompt. Tip #2: Tell the AI "You are an expert at strategic thinking, problem solving, design, and option generation. When asked to solve a problem you come up with creative, clever, interesting ideas. Our first task is to _____ (e.g eliminate hunger from the world). Describe the details of each idea.[70]
- What is needed to increase *food production* in ____ (location where problem area is severest).
- Who is needed to do this (the above)?
- What resources are needed to make this happen? (to implement *Increased food production*)

70 For other techniques, see Ethan Mollick, "A prosthesis for imagination: Using AI to boost your creativity". https://www.oneusefulthing.org/p/a-prosthesis-for-imagination-using

- What will it cost to do _____
- How much money would it cost to reach the ideal state/eliminate hunger, feed everyone in the world?
- Where could the money needed to do _____ come from?
- What are possible outcomes of _____ (e.g. eliminating hunger, implementing a particular strategy or solution).

Summary

A design science plan should be grounded in our vision of an achievable Preferred State, not a speculative fantasy. It needs to show how, using present day technology and resources we can achieve the Preferred State. Our Preferred State, and the plan for reaching it should not be confined to present modes of thinking, political constraints, or projections of what is likely to happen. It should be based on what we want to make happen and our explicit design for making real our preferred vision.

Design science deals with what is technologically possible but not necessarily with what is politically probable. The primary constraints on the plan are technological (is it possible given current know-how?) and ecological (is it compatible with and supportive of natural systems?).

Can it be implemented, minimally, without ecological damage? And optimally, can its implementation help regenerate ecological systems? Does the implementation plan use what is currently available in resources, technology, and know-how? For example, nuclear fusion could not be included in an energy plan because fusion is presently not a technologically feasible energy option. (It could also have a number of other characteristics that are counter to our evaluation criteria.)

A design science strategic design is based on what we want and what is possible. It shows how a system could be organized to fulfill our preferred values and goals. It becomes and is real to the extent that we can organize ourselves and the environment to realize the plan. In some ways, this planning stage can be likened to what an architect does in designing and specifying the elements of a new building or system of buildings. Resources, needs, wants, potentials, and constraints are all integrated into an image—a blueprint—of a preferred system. This part of the design science process is the development of our "blueprint." Implementation takes the blueprint and gets it "built" in the real-world.

A helpful exercise in developing a long-range strategy is to describe the preferred system and to work backward to the present describing the necessary steps that lead to our goal. As we work backward to the present, we will find it is helpful to frame the different steps in the prevailing social context so that the plan appears both logical and implementable. For example, we could identify actual institutions, organizations, agencies and individuals either engaging in or capable of engaging in implementing our strategy.

Activities for you or your team to do — Questions

1. What artifacts (physical— technology— and metaphysical— policies) are available to move from the present to the preferred state?
2. For what geographic, climatic, and ecological conditions is our solution appropriate?
3. Does your strategy require the development of new artifacts?
4. What criteria are you using to evaluate artifacts or alternatives?
5. What are the indicators you have selected to measure progress towards the preferred state?
6. Have you identified any trim tabs/tipping points that might accelerate adoption of the strategy?
7. What synergies can be realized by your strategy? Where are there win-wins or win^{n}-wins?
8. Who will the plan impact? How can these people, and their perspectives, needs, culture and economy be involved with the design of the plan?
9. How risky do you think the strategy is? What could go wrong?

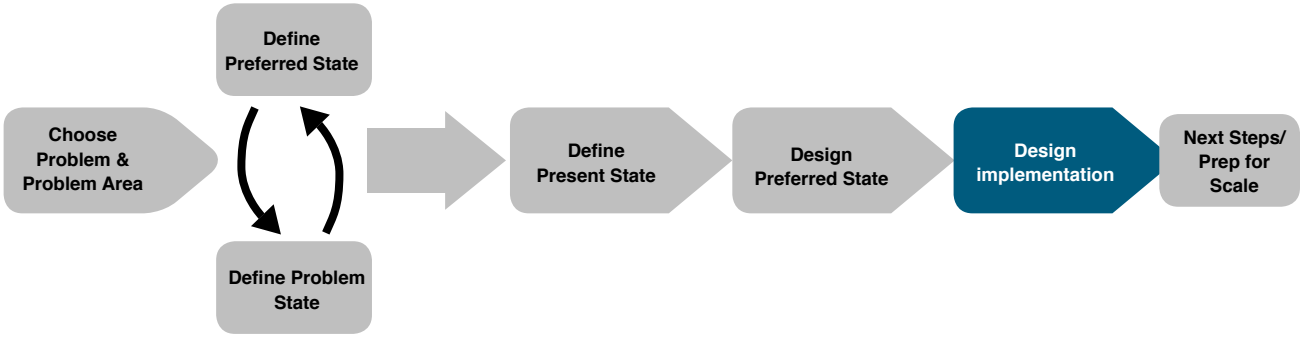
PART 4

IMPLEMENTATION—TAKING THE INITIATIVE

Part 4 Provides a method for making real your design, your solution to a problem, your path to achieving the Preferred State.

"The difficult I'll do right now
The impossible will take a little while."

— Bob Russell



Design Implementation

> "The design scientist undertakes fundamental invention, self-underwriting, development and experimental proof of inventions, as demonstrated for instance by the Wright Brothers, wherein the design science professional will be equipped with all the economic, legal and technological knowledge necessary for reducing such inventions to on-going industrial practice. "
>
> — Buckminster Fuller

Up to this point we have discussed the step-by-step method by which we can determine what needs to be done and how. Now comes the next steps in the design science process— those needed to start the implementation of the plan.

There are three ways for us to further develop our work and to help bring about positive change. We can:

1. *Develop the tools or artifacts* called for by the design science strategy we have formulated (if they don't already exist, as in the example Fuller provides above about the Wright Brothers). And if they do exist, in part or whole, we can test them out in the configurations we have designed to see if our design works as we intend.
2. *Communicate the plan* to those who could be involved, affected, or interested in getting involved as an NGO, government agency, funder, concerned community group, or as a business proposition or investment. In other words, whomever has values and interests that match the initiative we are seeking to start, and would benefit from its implementation.
3. *Initiate a larger planning process* that includes obtaining the participation, collaboration, or partnership of those who would be involved in implementing, funding, sponsoring, testing, or benefitting from the plan.

Developing the artifact

The design science process provides us with a rationale and a frame of reference for what is needed. *"What is needed"* can often be translated into a physical or "meta-physical" *artifact* that will get us to the Preferred State.[71]

This is the first and most important output of the design science process. Since the implementation of our strategic design/plan will require developing artifacts that may not have yet been invented, tested, or configured in the manner which we are proposing, we need to compile a list of the artifacts that need to be "invented" (or put together) to make our strategic design real. Along with the artifact, we need to state the specifications for its performance and what it is to accomplish. These performance specifications (or design criteria) are specific guidelines for what the artifact is intended to do, as well as its impact on humans, materials and energy usage, safety, performance, ecological impact, efficiency, and adaptability.

The global design science strategy formulated in the book *Energy, Earth and Everyone*[72] is an example we will use to illustrate this process. It points to the need to harness Earth's income or renewable energy sources to meet the energy needs of everyone in the world in a clean, abundant, and sustainable manner. One example from this book follows.

After studying the energy flows and concentrations through the whole Earth system, the vast wind power potential of Antarctica emerged as a potential source of energy. Because of the unique and intense conditions in Antarctica, a special artifact is needed to harness these winds. Most windmills built to date have been primarily designed to harness low intensity winds of the planet—winds blowing from 11 to 40 km/h (7 to 25 mph). Winds above these limits may result in damage to the windmill, and they are therefore designed to shut down if the wind is too strong. Winds in parts of Antarctica average over 45 km/h (28 mph) for 340 days per year and often exceed 160 km/h (100 mph). To harness these winds, a wind turbine specifically designed for high-speed winds in very cold and hostile conditions is needed.

Once an artifact, in this case a wind turbine capable of functioning in the Antarctic, has been identified, it can be built, tested, refined, and then utilized to meet the stated need. Designing, building, and testing the artifact involves a specific design science process. This process is a systematic outline for designing an artifact.

In Figure 31, the box in the lower left, *Artifact Development*, is the area where the idea for the artifact is developed into a design and workable prototype. This first prototype is tested and refined into Prototypes 2 and 3. As preparation for this stage, the design scientist first searches for related or similar designs. If similar work has already been done, there is no reason to repeat it. We can learn from previous work and build on it.

71 "Meta-physical" artifact is a policy, a non-material arrangement or procedure that changes the systems with which we are working. Economic incentives or disincentives to instigate or stop certain actions that engender positive change towards our Preferred State are one example.

72 Medard Gabel, *Energy, Earth and Everyone* (New York, Doubleday; 1980)

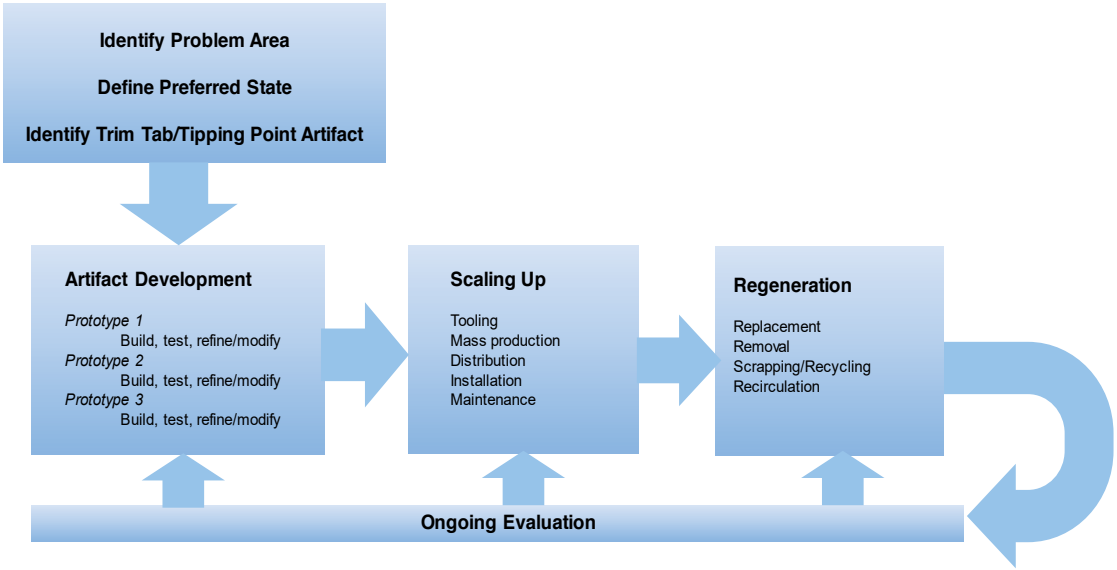


Figure 31. The design science process for artifact development

In the Antarctic wind energy example, we need to see if there is already a high strength windmill or a design for one that can be adapted. In addition, we will need to consider rotor design and construction, tower design and construction, specific weather and geographical conditions in Antarctica where is the best spot for a forest of windmills in the Antarctic from the point of view of the wind, from the point of view of construction, logistics, materials science (which materials are best suited to the Antarctic extremes), environmental impact, and getting the power produced to the places where it will be used.[73] Contact information for companies, agencies and authorities with relevant technical expertise and local knowledge needs to be assembled.

The next step, after all the relevant information has been gathered, organized, and integrated, is to begin the actual design to be tested. As Donald Norman[74] points out: "The testing should not start with completed, working objects because then it is too late to make changes. It can start with rough sketches (even on napkins). Then it can move on to diagrams, simple mock-ups using simple display programs for software and foam or cardboard constructions for physical products. Each iteration does get closer to the final version. These rules are true for complex physical devices, for software, for a procedure or checklist – for everything".

A first prototype is built. If parts for the artifact are available, they are integrated into the desired unit.

73 The strategy in *Energy, Earth and Everyone* coupled wind powered electricity generation with hydrogen production. Liquid and gaseous hydrogen was then transported from Antarctica.

74 Donald A. Norman, *Design for a Better World: Meaningful, Sustainable, Humanity Centered* (MIT Press, 2023).

If an artifact is not available, then we need to begin to fabricate the artifact from "scratch." What we are able to do ourselves is dependent on our unique background, training, skills, inclinations, demands of the design, and available resources. We may need funders or investors so we can hire the relevant expertise and skill sets to build and test prototypes where we cannot do that work ourselves.

The design scientist is often a synthesizer, an integrator of already existing parts into new synergetic arrangements. Obviously, an individual cannot mine, refine and alloy the various metals needed for a windmill, nor should they be expected to have all the skills necessary to reduce a complex idea to a physical artifact. *The design scientist needs to be skilled in knowing how to get anything that needs to be done, done.* This entails knowing who can do what, and where, when, and how. One very beneficial side effect of this process is that the design scientist can obtain a comprehensive education by following his or her idea through to completion. Many skills and talents are brought into focus at one time or another in the process of reducing an idea to ongoing industrial practice.

Once the first prototype is built, it is then tested and improved into a second prototype. It is necessary to repeat this cycle of prototyping, testing, and refining multiple times to work out any bugs and to continually improve the design.

The prototyping of an idea, and the subsequent testing of that idea as a physical artifact (or meta-physical policy) to see whether it is a viable alternative, can be done by an individual or group. If possible, it will involve those who will be affected by the design. The next stage, if the strategic design calls for a physical artifact, is the actual industrial manufacture of the working prototype, the production design, tooling, production, and subsequent distribution, installation, maintenance, and service. Because these steps usually require more resources than an individual or small group could bring to bear, the active support of a much larger group, the other two outputs of the design science process, "communicating the plan" and "initiating a larger planning process" enter the picture.

DEVELOPING THE TOOLS OR ARTIFACTS— FURTHER DETAILS

Once we have designed the strategic design and plan for reaching our preferred system the next questions to be resolved are:

1. *How* do we get from here to there—from the Present to the Preferred State? What is our Implementation Design/Plan? How does it work? What does it do?
2. *When* will we get there, and are there intermediary goals along the path?
3. What stages and levels of implementation do we have to consider? A strategic implementation plan is an arrangement of all the steps that must be completed along a timeline showing the order in which they must be done. At the left end of Figure 32 is the present problem and at the right is the proposed preferred future. Along the timeline will be the "things which need to be done" to get to the Preferred State.
4. The communications plan – who needs to be informed, when, and what is needed from them?
5. How do we track progress, and course correct when required?

6. What resources – materials, energy, information, partners, sponsors, people, money – are required to achieve the preferred system?
7. How will progress on the implementation plan be monitored to ensure it is progressing and achieving the Preferred State?
8. How will the plan be amended or modified based on the results of the tasks completed to date?

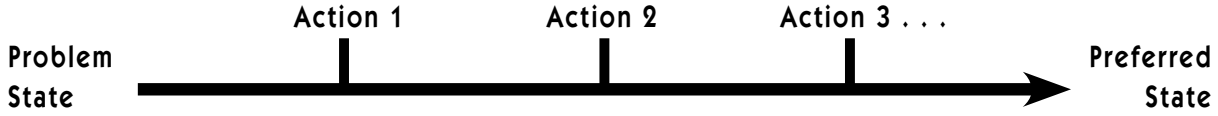


Figure 32. A timeline shows the sequence of actions to go from the Problem State to the Preferred State

Target Date for Realizing the Preferred State

In designing the Preferred State, we imagined an 'idealized' design that did not have a date for when it would be realized. This was deliberate, in that we did not want to be constrained by the obstacles in getting there. Now that we have a design for the preferred system, our attention turns to how to achieve that, and when it can be realized, recognizing gestation rates (and our ability to influence those), stock turnover rates, resource availability, and the need to implement the preferred system design as quickly as possible.

Actions Needed to Implement the Strategy for Achieving the Preferred State

There are two major ways of dividing a strategy. The first is to separate the implementation steps into different aggregate levels such as individual, single dwelling unit, neighborhood, community, region and global. The next breakdown is to further subdivide each of these levels into the different functional areas. For example, we might want to divide the implementation steps of a regional food system into the following functional subsystems: food production, transportation, processing, storage, distribution, consumption, waste recycling, etc.

Test/Proof-of-Concept Phase

Part of the design science process is to test a prototype or proof-of-concept of the proposed solution, and that may be a near-term tasks. Doing this in the most relevant locations to the problem area we are focused on is important. After developing our strategic design and plan it is important to pick an area in the world – a country, region, specific town, or spot where we want to test the solution and examine

the relevant environmental, social, economic, and cultural conditions of the geographic area for which the test/proof-of-concept is to be implemented. For example, if we are designing an energy system, we might list energy needs and for what (electricity, cooking, heating, cooling, etc.) solar intensity, climate, ecosystem type, available resources, etc.

- Where will the prototype, test, or proof-of-concept be done? What country, region, town/village?
- Who will be involved and impacted by the test?
- What will be tested? What are the expected and desired outcomes? What is needed to justify, to make a compelling case, for the scaling of the proposed strategic design and plan to the rest of the country and world?
- What are the results of the test? What did we learn? What can be improved?

Scale-up—The implementation timeline

Nearly every design science solution and strategy for implementation needs to go from idea to prototype/proof-of-design and testing to full-scale implementation. It needs to grow from a seed to a forest. To enable that, the design needs to find receptive and nurturing "soil" in which to be planted, the water and nutrients it needs to flourish, and ongoing care to make sure everything is going well, and to make ongoing adjustments to unanticipated events.

This complicated, and often lengthy process is made increasingly possible and benefits from partners. These could include partners on the ground (such as local in-country NGOs where the prototype will happen), collaborators, sponsors, funders, and where and when needed, government officials. Scaling the solution is where the communication plan of the strategy/solution becomes critical.

Table 12. Some of the questions that need to be dealt with in scaling our design

Design/solution is a physical artifact	Design/solution is a metaphysical artifact–a policy, organizational innovation, etc.
What are the material resources, tools, space, and skills needed to build and test our prototype? How will the strategic design and implementation plan be evaluated and improved? Once positive test results of the prototype/proof-of-concept are in, what happens next? Who will implement the next stage, where, when? What are the resources needed to make that happen?	Who/what organization/agency/government can implement our design? Who is in charge of that organization? How will we determine and contact the relevant people who can implement our design? Who influences policy at the organization? What is the larger system of which the organization is a part? How can we communicate our design to the public and other constituencies? How can our design be tested and a proof-of-concept be conducted?

Critical Path

What stages of development must occur at what point during the overall implementation period? This kind of scheduling is "determining first things first" or critical path planning. For example, a hydrogen-powered transport vehicle and its fuel supply has to be prototyped, tested, and proven feasible before a transportation system using this vehicle can be designed and implemented.

In developing a complex strategy, it may become clear that all the steps cannot be included on a single timeline. In this situation we need to divide the strategy into a number of timelines. These lines can be either parallel or overlapping.

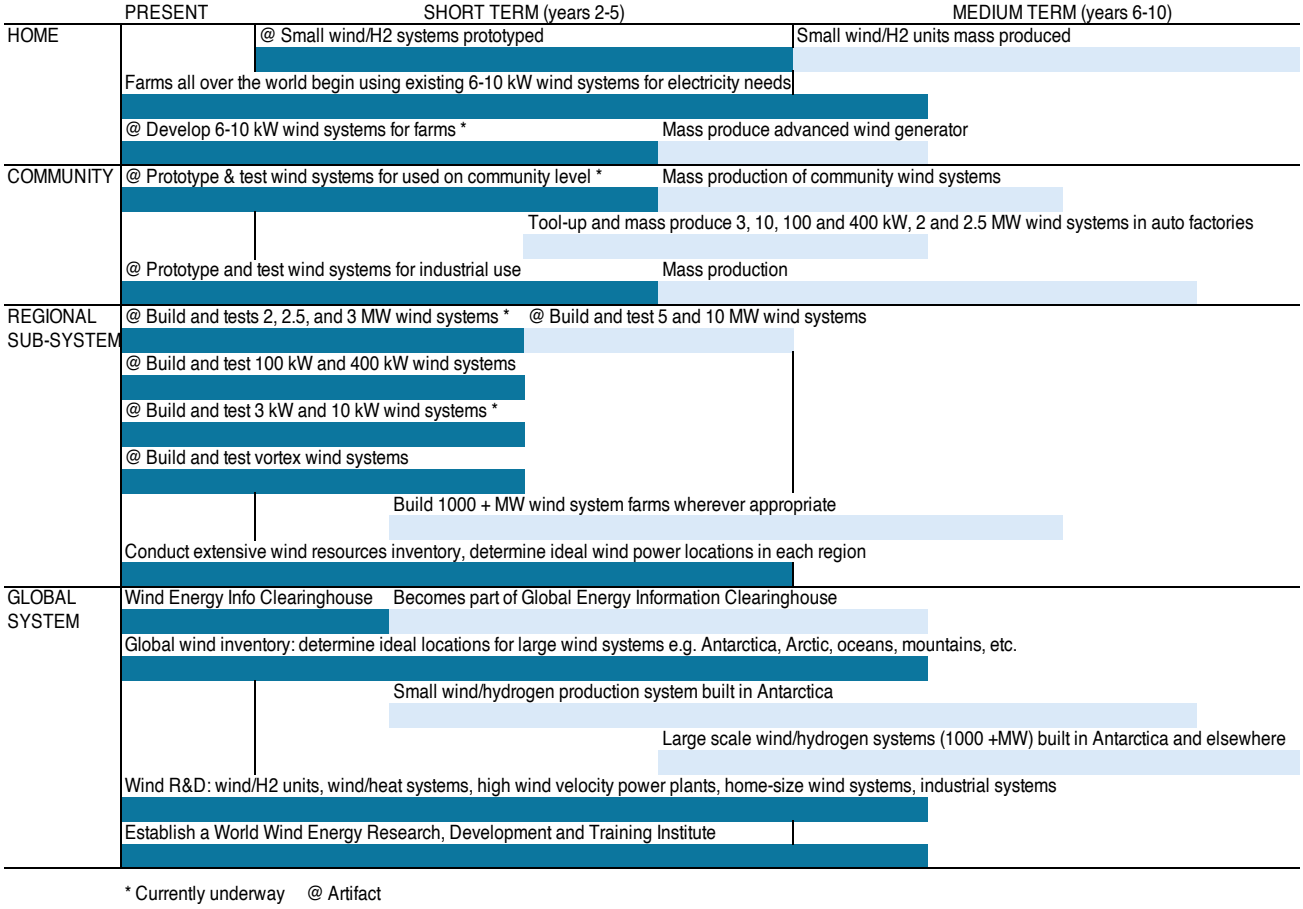


Figure 33. Timeline for the wind energy component of a global energy strategy

Figure 33 is an example of a sub-strategy of a global energy development plan proposed in *Energy, Earth and Everyone.*[75] The development of wind power is described at different aggregate levels along a ten-year timeline..

In developing the timeline, it will be important to identify near-term tasks that are particularly critical for achieving the overall timetable. This helps ensure that progress on the goal is not postponed until the last moment.

Documenting the process/Communicating the plan

Throughout the design science planning process, it is important to record our research progress and group sessions. This documentation provides the raw material to produce a publication that can communicate our work to a larger audience.

While the objective of our group may not be to publish and distribute a finished foundation proposal, business plan or document at this time, recording the progress of the work is often the best way to "store" the generated information for future referral. A Google doc or similar group-accessible document platform is useful for this task—as well as throughout the design process.

The Global Solutions Lab[76] has used a variety of tools to document the work of the Design Teams that comprise the Lab. One tool has been an online wiki that documents progress. Another is a Google doc. Both come with pre-loaded questions, the answers to which are the design science strategic design and plan. Another technique is a series of slides that contain the questions. The slides with the questions answered are used as part of a daily presentation by each Design Team. The purpose of this is so that the entire Lab knows what everyone is working on, plus the whole Lab can offer feedback, suggestions, and data sources they have come across in their work that might be helpful. It is a way for the entire Lab to work together on improving each of the strategies, as well as a way for Lab participants to practice presenting their work. At the end of the Lab these slide shows become the basis for presentations to a team of evaluators who provide feedback. (The questions used in the Global Solutions Lab, and elsewhere, are presented in Appendix 1.)

The goal of the documentation process is to have what amounts to a business plan or collaborator/partner/sponsor/foundation proposal for collaboration or investment for the next stages of the design science process. Such a document needs to show, among other things, the need, what our strategy will do, and how much it will cost to take to the next stages. This recognizes the fact that there are not many people who are in a position to self-finance the development of a strategic design. At some point, the design scientist will likely need to seek resources that go beyond their financial wherewithal. Where this point is depends on what the overall strategy is, what artifacts are necessary to be developed and tested, the resources of the design scientist, and other factors.

75 Medard Gabel, *Energy, Earth and Everyone* (New York, NY: Doubleday, 1980).
76 https://designsciencelab.com

The documentation stage is crucial to the entire process. Whether it is a business plan, foundation proposal, crowd-funding proposal, policy white paper, journal article, chapter in the *Designs for World That Works for All* or other book, part of the online *Global Solutions Database*, or all the above, the design scientist needs to be able to communicate their work to the larger system (that of society, investors, partners, hosts, etc.) so that the strategic design gets *implemented*. It does no one any good to have a brilliant strategy that can improve the world sitting on the shelf gathering dust.

The work that we produce will also be useful to other groups that follow. The more thoroughly the entire process is documented the more valuable the report will be to us and to other groups.

Design science teams need to document their work using all or a combination of the following tools:

- Research reports
- Charts/graphs
- Drawings
- On-line presentations, TED Talks, YouTube presentations
- Physical models
- Photography
- Power Points
- Web sites
- Bibliographies.

THE COMMUNICATIONS PLAN

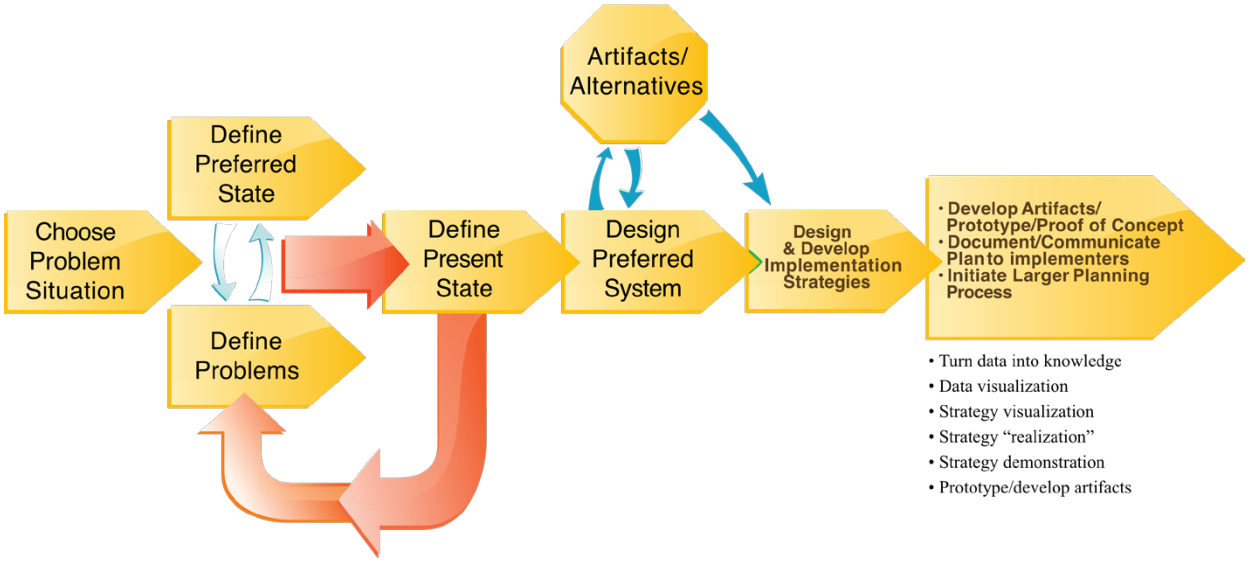


Figure 34. The final step in the design science methodology is implementation.

The design for achieving a Preferred State that we develop may be beyond the resources to which we have access. In these cases, we need collaborators, partners, sponsors, and funders. To achieve this we need to develop a powerful communications strategy that reaches the right individuals and organizations in terms that are appropriate to each. It can be put together as a business plan, foundation proposal, report or short video that can be sent out to others in the field and related individuals, groups, corporations, organizations, and government agencies that were identified during the planning process. It can be sent out for evaluative feedback or for seeking partners or funders. Another, more general document also needs to be written and distributed to the public to get as many people aware of our strategy as possible.

The discussion needs to include all stakeholders, or the capacity building that is critical to any endeavor will not reach its potential.

The nation state is no longer the only major player on the global stage. Global corporations, cities, nations, NGOs, and private citizens all need to work together on getting what the world wants.

If the "problem" being addressed is to be solved (and stay solved), decision making at the local level and input from all sectors of local society are needed. This provides learning and growth opportunities for the larger system of which the problem is a part. Every development strategy is an opportunity to increase the knowledge and capacity of the society in which development is occurring.

This task is a critical part of the design science process. We don't want our designs to sit on a shelf, never seeing the light of day, never solving the problems that afflict those in need, never achieving our preferred state. The following are what needs to be considered when preparing such documents:

- What needs to be communicated to potential collaborators? What is the essence of our design, and how does it overlap with the values, goals, and priorities of our potential partners?
- What parts of our design are the most newsworthy, that would garner the most attention of the general public?
- What needs to be communicated to people who will be part of the test site for the proof-of-concept of our design?
- Where and when appropriate, what government agencies, local leaders, entrepreneurs, corporations, possible sponsors/funders/allies should be alerted?

The general format for documenting design science strategies that are developed in the *Global Solutions Lab* and which are published online in the *Global Solutions Database*[77] and in the book *Designs for a World That Works for All*[78] are the following:[79]

- Title
- Authors (with their countries)
- Abstract
- Introduction/problem being addressed
- Preferred State
- Present State

77 https://designsciencelab.com/global-solutions-database/

78 Gabel and The Global Solutions Lab, "Designs for a World That Works for All: Solutions and Strategies for Meeting the World's Needs."

79 If your work follows the above organizational criteria, you are welcome to submit it for consideration to be added to the online Global Solutions Database at https://designsciencelab.com/global-solutions-database/

- Strategy and implementation of strategy
- What it is, how it works, impacts, needed resources to implement, test/proof-of-concept, timeline of implementation, costs and benefits and their distribution, and where funds will come from
- Endnotes

Developing the Implementation Plan with AI assistance

Some examples of prompts you might consider to assist in developing the implementation plan (for food/hunger related problem— *insert your chosen problem area*) include:

- What technology is needed to ____ (e.g eliminate hunger)?
- What policies or programs are needed to ____ (e.g eliminate hunger)?
- Which technology is the most efficient, effective, cost-effective, sustainable? What is a good test for _____ (one of the technologies from first prompt in this section)?
- Where is a good place to conduct this test?
- What is a plan for scaling the _____ (technology from first prompt in this section)?
- Where do we go from here/next/what can I do with $100,000 to move this strategy forward?
- Where could we get $100,000 to _____ (insert test of strategy)

Summary

The more comprehensive and anticipatory a strategy, the better its chances of bringing about the most positive long-term change for humanity. In developing a comprehensive strategic design and implementation plan, all the variables that affect the attainment of the plan should be considered. In defining the Problem and Present States, these variables are explored for their effect on the problem situation and the prospects for achieving the Preferred State.

QUESTIONS ON YOUR IMPLEMENTATION STRATEGY

1. What artifact needs to be developed? Is it a physical artifact or a "meta-physical" artifact?
2. What are the steps of your implementation plan? What items are on the critical path and need immediate attention? What in the short term? What in the medium term?
3. What resources are required to implement your plan?
4. Does your implementation plan address all aspects of your preferred state?
5. What industries, commercial services, countries, areas, organizations, partners/allies, hosts, funders and people need to be involved in your strategy?
6. Who will support the plan? Who is likely to be opposed, and how can their concerns be addressed?
7. What resources have you developed to communicate with those who need to be involve?
8. What plan do you have to involve those who will be affected by strategy?
9. How will you monitor progress of the implementation?
10. What systems are in place to modify the plan in light of experience?
11. What form has your documentation of the strategy taken?

CONCLUSION AND NEXT STEPS:

TAKING THE INITIATIVE— WHERE WE GO FROM HERE

> "The world is in a race between education and catastrophe."
>
> — H. G. Wells

A design scientist sees a problem, a situation that shouldn't be, sees what could be, and decides to take the initiative and do something. A design, a strategic plan of action is developed that eliminates the problem. At the core of that design are one or more artifacts—technology, policies, and their implementation— that achieve a preferred state where the problem no longer is present.

To verify and test the strategic design and plan the various artifacts are developed, prototyped, and tested, then mass produced and distributed, maintained, replaced, and recycled when there is an improvement available. This strategic solution is documented, made widely available, and feedback elicited. Where appropriate, a local planning process is instituted in the specific areas where the strategic design and plan has furnished new alternatives and can, when implemented, reach the Preferred State.

Design science defines visionary goals, develops new options, and solves real-world problems. It involves a long-range perspective which includes the knowledge that everything has its own gestation rates. For a human baby, it is 9 months, for an elephant it is 21 months, for an artifact or comprehensive design strategy it can be considerably longer. The iPhone was initially conceived of in 2000,[80] and came to market in 2017. The first fax machine was invented in 1843, but only became popular with consumers in the 1980s.[81] design science seeks to accelerate the development of viable solutions to global and local problems.

As in any long-distance voyage, periodical navigational fixes are taken, and subsequent course corrections are made in order to "stay on course." The same applies to the long-range goals of design science. New information will alter the existing information; as goals are approached, they take on greater clarity and possible new goals emerge.

Tools for Changing the World is intended, as stated in Part 1, to provide a set of tools for changing the world. It is intended to provide perspective and a methodology for participating in the solution of problems that will help the world meet our needs using available technology (or inventing new alternatives), for winning that race between education and catastrophe.

Hope is where values, vision and experience meet the future. *Tools for Changing the World* seeks to foster hope as it provides techniques for transforming values and vision into solutions to real-world problems—hope made real. It seeks to channel and organize imagination and science to develop innovative and viable solutions to critical real-world problems. Its success will be measured by what we do with the information contained in this document, plus our knowledge, experience, initiative, and dedication.

> The world will not be destroyed by those who do evil, but by those who watch them without doing anything.
>
> — Albert Einstein

It's now up to you. We call on you to take the initiative.

80 National Institute for Research in Digital Science and Technology, "Jean-Marie Hullot, from Perforated Cards to the iPhone." National Institute for Research in Digital Science and Technology.

81 Bellis, Mary. "History of the Fax Machine." *ThoughtCo.* (blog), March 20, 2019. https://www.thoughtco.com/history-of-the-fax-machine-1991379.

Initiative is a natural, and often bold, response to a situation of which you, and perhaps only you, are aware. Your ability to respond transforms into responsibility by your awareness, values of what is right and wrong, and vision of what should and can be.

You act.

You take the initiative and solve the problem, resolve the situation. Make the world a better place. *You* taking the initiative is where it begins.

We give the final words to Buckminster Fuller:

"Initiative springs only from within the individual. Initiative can neither be created nor delegated. It can only be vacated. Initiative can only be taken by the individual on their own self-conviction of the necessity to overcome their conditioned reflexing which has accustomed them heretofore always to yield authority to the wisdom of others. Initiative is only innate and highly perishable."

APPENDICES

1. Global Solutions Lab design science questions
2. List of online statistical data sources
3. List of Solutions Libraries
4. Bibliography/Reference

APPENDIX 1 GLOBAL SOLUTIONS LAB

The Global Solutions Lab[82] uses design science to develop innovative and regenerative solutions to the critical problems facing humanity and for achieving one or more of the UN's Sustainable Development Goals. Participants come from around the world and work together in cross-cultural, interdisciplinary, multi-generational Design Teams. The results of the Lab's work are published online in the *Global Solutions Database*[83] and in book form in *Designs For A World That Works For All*.[84] The usual format of the Global Solutions Lab runs for two weeks. As such, it uses an abbreviated form of the design science process. This process is organized as a series of questions. The answers to the questions result in the first draft of a design science strategic design and implementation plan. These questions are below:

1. What is the topic, issue or problem area being worked on?
   a. The general human or environmental need area our team is focusing on is …
   b. The specific problem situation we are working on is …
   c. The Sustainable Development Goal we are seeking to achieve is . . .
2. Your Design Team
   a. What is the working title of your project and Design Team?
   b. Who are the members of your Design Team? (List names and country of origin.)
3. What is the Preferred/Ideal State for the problem area we are working on?
   a. The Preferred State for the global problem situations we have picked to work on is . . . (List the qualities of your Preferred State)
   b. Prompts: Who does it reach/impact? What does it do? What does it look like?
   c. What will the world look like if this problem is solved/the preferred state is achieved?
   d. How will your Preferred State be measured? (How will we measure success? List statistical indicators.)
   e. Prompts: What are 3 to 4 barriers to reaching the Preferred State?
   f. How will we know when we have reached the Preferred State?
4. What is the Problem State?
   a. The global problem state for (our problem area) is . . .
   b. What are the visible symptoms of the problem? The quantitative description of the problem is . . . (how many of what, etc.)
   c. How many people are impacted? Where are they, etc. See: https://sdg-tracker.org/

82 Global Solutions Lab, https.designsciencelab.com
83 https://designsciencelab.com/global-solutions-database/
84 https://designsciencelab.com/resources-ii/

d. How can we measure the severity of the problem? See: https://sdg-tracker.org/)What is the cost of the problem — in terms of money, life expectancy, health, environmental harm, impact on local and global economy, etc.?
e. What happens if nothing is done?
f. What is the direction the problem is moving in? (What are the trends?)
g. What are the implications of the problem— how does it impact other areas and systems?
h. What are its interconnections with other problems? (This problem impacts the food [shelter, health, education, transportation, economic, environmental] system in the following ways:
i. What does the problem look like? What images, graphics, charts and maps can describe the problem? What is the human face of the problem?
j. It is most severe in . . .
k. The problem is most severe in . . .
l. What is the geographic distribution of the problem? Map the problem.
m. What is the cause of the cause we named above?

5. What is the Present State? (The Problem State is a part of the Present State– what does the larger system, the Present State, look like?)
   a. What are the components and processes of the Present State?
   b. What are the inputs and outputs of the Present State?
6. Problem, Preferred, Present State Summary
   a. This is where we are:
   b. This is where we want to be:
   c. This is the gap between the two:
7. What are the alternatives/options for reaching the Preferred State?
   a. What present day technology or policies can be used that will get us to the Preferred State?
   b. What input/outputs can be modified? What components/processes can be changed? What new technology is needed?
   c. What artifacts/technology, if scaled up/mass produced/disseminated could get us to the Preferred State?
   d. What present day technology can be scaled up to have the impact needed to reach the Preferred State?
   e. What organizations are needed?
   f. How is the needed technology organized/ used/deployed?
   g. How many of what will be needed?
   h. What could we get a patent on?
8. What is the design/plan for reaching the Preferred State?
   a. What happens?
   b. The Preferred State for the (problem area/ situation) we are working on is:
   c. This is how we will get to the Preferred State:
   d. How will we do that? (. . . and how will we do that? Keep asking "how" until we reach something very specific, something that we and your colleagues could do, with funding or partners.)
   e. When, what year, will your design/plan get us to the Preferred State? We will reach this Preferred State in the year 2___.

f. In the next 6 months the design/plan we need to do the following to get us to the Preferred State:
g. In the next year we need to do the following to get us to the Preferred State:
h. In the next 5 years we need to do the following to get us to the Preferred State:
i. What impacts will this strategy have?
j. What will the world (or region we are focused on) look life if this problem is solved using your design/plan?
k. How will we measure success? How will we know when we reach the Preferred State?
l. We will know we have achieved the Preferred State when . . .

9. More Details/Specifics/Summary for your design/plan: What is the Plan for *implementation* of your solution?
   a. Plan —Artifacts
      - What artifacts will the plan use to reach the Preferred State?
      - The strategy will use the following artifacts to reach the Preferred State:
      - How many?
   b. **Plan— Proof-of-concept** What is the proof-of-concept (what is needed to justify scaling your design/strategy up)?
   c. Plan —Timeline
      - What do we do in the next six months to reach the Preferred State? In the next six months we will …
      - What needs to be done over the next year, five years?
   d. Plan—Impacts
      - What impacts will this strategy have on other areas?
      - What are the expected and measurable outcomes of this strategy?
   e. Plan — Resources
      - What material resources does this plan need?
      - What human resources does this plan need?
      - Who will implement your design/plan?
      - Who is needed for its success?
      - The strategy needs the following material resources:
      - The strategy needs the following human resources (Who will implement the strategy? Who is needed for the strategy's success?)
      - Where are they? How do we get them?
      - What technology is needed? How do we get it?
   f. Plan—Cost
      - How much will our strategy cost? The strategy will cost approximately …
      - Where will this money come from/how will this strategy be financed?
      - The money will come from …
   g. Plan—Who can do it? How do we start? Who does what?
      - What could *government* do to get your strategy implemented?
      - What could a *business* do to get your strategy implemented? Is there a business opportunity in your strategy for meeting one or more of the SDGs?

- What could an *international organization*, such as the UN, do to get your strategy implemented?
- What could an *non-governmental organization* (Save the Children, Greenpeace, Project Drawdown, etc.) do?
- What could a *philanthropic organization* do to get your strategy implemented?
- What can *individuals* do?

h. Plan —You
   - What could *you* do to get your strategy implemented?
   - What can you do to make this strategy real?
   - What could you do with $100,000 to move this strategy to the next level?

APPENDIX 2 Global statistical data sources and data analysis tools

(The below listing is available online, with links at the Global Solutions Lab website: https://designsciencelab.com/global-data/)

United Nations

SDG Global Database

https://unstats.un.org/sdgs/unsdg

Data on more than 210 SDG indicators for countries across the globe by indicator, country, region or time period

AIDSinfo

http://www.unaids.org/en/dataanalysis/datatools/aidsinfo/

Statistical resource on AIDS and HIV worldwide.

DESA - Statistical Databases

https://www.un.org/en/desa/products/un-desa-databases

Collection of the UN Department of Economic and Social Affairs (DESA), Statistical Division databases, including commodity trade statistics, census knowledge, disability statistics, good practices, joint oil data, millennium data indicators, population, and social indicators.

ESCAP Data Centre

http://www.unescap.org/stat/data/

Statistical database of ESCAP (Economic and Social Commission for Asia and the Pacific). Includes population, health, education, labor, infrastructure, finance, trade, environment, gender, and other statistics.

FAO Statistics

http://www.fao.org/corp/statistics/en/

Links to various statistical databases of the Food and Agriculture Organization, including Agro-MAPS, AQUASTAT, CountrySTAT, FAOSTAT, Fishery and Aquaculture Statistics, Forestry Country Profiles, GLIPHA, PAAT Information Systems, and TERRASTAT.

FPMATool (UN FAO)

https://fpma.fao.org/giews/fpmat4/#/dashboard/home

An online database and analysis tool with easy access to consumer food price data in about

86 countries and 81 benchmark international commodity series.

ILO Statistics and Databases

http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm

Collection of statistics and databases compiled by the International Labour Organization: core labour statistics, country-level data, child labour statistics, occupational health and safety, conventions and recommendations documents, reference literature, and labour legislation.

ICT-Eye

https://www.itu.int/net4/itu-d/icteye#/

ICT-Eye is an International Telecommunication Union (ITU) resource for information and communication technology indicators and statistics, regulatory and policy information, national tariff policies and costing practices, and more.

Standard Country or Area Codes for Statistical Use

https://unstats.un.org/unsd/methodology/m49/

The list of countries or areas contains the names of countries or areas in alphabetical order, their three-digit numerical codes used for statistical processing purposes by the Statistics Division of the UN Secretariat, and their three-digit alphabetical codes assigned by the International Organization for Standardization (ISO). The designations employed and the presentation of material at this site do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

StatBase - Economic Commission for Africa

https://ecastats.uneca.org/data/

Browsable and searchable statistical database for ECA (Economic Commission for Africa).

UN Data

https://data.un.org

UNdata brings UN statistical databases within easy reach of users through a single-entry point. Users can now search and download a variety of statistical resources of the UN system from a wide range of departments and subject matter.

UN COVID-19 Data Hub

https://covid-19-data.unstatshub.org/

Data relevant to COVID-19 response readily available as geospatial data web services, suitable for the production of maps and other data visualizations and analyses, and easy to download in multiple formats.

UN e-Government Knowledge Database

https://publicadministration.un.org/egovkb
https://publicadministration.un.org/egovkb/en-us/Data-Center

E-Government Development Index at country, regional, city levels.

UN Global SDG Indicators Database

https://unstats.un.org/sdgs/indicators/database/

To fully implement and monitor progress on the Sustainable Development Goals, decision

makers everywhere need data and statistics that are accurate, timely, sufficiently disaggregated, relevant, accessible and easy to use. The Open SDG Data Hub promotes the exploration, analysis, and use of authoritative SDG data sources for evidence-based decision-making and advocacy. Its goal is to enable data providers, managers and users to discover, understand, and communicate patterns and interrelationships in the wealth of SDG data and statistics that are now available.

UN LDC Data

https://www.un.org/development/desa/dpad/least-developed-country-category/ldc-data-retrieval.html

The Committee for Development Policy (CDP), a subsidiary body of the Economic and Social Council (ECOSOC), advises the Council on a wide range of issues that are relevant for the implementation of the 2030 Agenda for Sustainable Development. The CDP uses three criteria to identify countries as least developed and reviews the list of LDCs every three years. Official data used in these triennial reviews of the LDC category since 2000 can be downloaded in Excel format.

The CDP Secretariat has also produced time series estimates of the LDC criteria providing information of countries' progress towards the LDC criteria from 2000 onwards. The dataset differs from the official triennial review dataset due to data revisions, changes in data sources, methodological changes and most notable, changes in composition of the composite indices HAI and EVI.

The CDP decided in 2020 to enhance the graduation framework by introducing a set of supplementary graduation indicators (SGIs). These indicators describe vulnerabilities not fully captured by the LDC criteria and other factors relevant for graduation. The SGI dataset, including a visualization of the latest available data can be downloaded. More information on the dataset can be found in the explanatory note.

UN World Population Prospects

https://population.un.org/wpp/

This database is the core of the latest Revision of World Population Prospects, the United Nations estimations and projections of population for all countries of the world, covering the period 1950-2100. It incorporates the findings of the most recent national population censuses and of numerous specialized population surveys carried out around the world. The latest Revision provides the demographic data and indicators to assess trends at the global, regional and national levels and to calculate many other key indicators commonly used by the United Nations system.

UN SDG Acceleration Action Database

https://sustainabledevelopment.un.org/sdgactions

The SDG Acceleration Actions online database is a tool to help inspire and mobilize actions around the world to promote the implementation of the SDGs, as well as build resilience and bring inclusive recovery in the context of new realities post COVID-19, so that the global economy, planet and people we serve could emerge stronger together from the crisis. Check the distribution of SDG Acceleration Actions around the globe in this data visualization

dashboard: https://dsdg.maps.arcgis.com/apps/opsdashboard/index.html.

UN System SDG Implementation Database

https://sdgs.un.org/UNSDGimplementation

The UN System SDG Implementation online database is the UN family's repository of actions, initiatives and plans on the implementation of the 2030 Agenda and the sustainable development goals (SDGs). It contains information made available by UN system entities. It is searchable and is regularly updated. It serves as a useful reference tool for learning about what UN system entities have been doing in support of the implementation of the 2030 Agenda and the sustainable development goals (SDGs).

UN Comtrade International Trade Statistics Database

https://comtrade.un.org/

Free access to detailed global trade data. UN Comtrade is a repository of official international trade statistics and relevant analytical tables.

UNCTAD Statistics

https://unctad.org/statistics

Collection of statistical databases offered by UNCTAD (United Nations Conference on Trade and Development), including commodity price statistics, foreign direct investment, information and communication technology statistics, and trade control measures.

UNESCO - Institute for Statistics

http://data.uis.unesco.org

The Institute for Statistics Data Centre of UNESCO (United Nations Educational, Scientific and Cultural Organization) contains over 1,000 types of indicators and raw data on education, literacy, science and technology, culture and communication. Custom tables may be generated, and predefined tables are also available.

UNICEF - Country statistics

https://data.unicef.org/country/

Economic and social statistics provided by the UNICEF (United Nations Children's Fund) on the countries and territories of the world, with particular reference to children's well-being. The statistics are published annually in the organization's flagship publication. It includes tables combining statistics for all countries.

UNWTO e-Library

https://www.e-unwto.org/

Information source offering access to research and information in the area of tourism. The UNWTO e-library contains books, journals and statistical reports by country and by indicator.

UPU Postal Statistics 2022

https://www.upu.int/en/publications/statistics/postal-statistics-2022

The Universal Postal Union's (UPU) statistical database provides a dynamic overview of postal development in each member country. It includes data for each member country, and summary tables by heading.

UN-Habitat Urban Data

https://data.unhabitat.org

Free and open access to data about countries and cities around the globe. Data available analyzed,

compiled and published by UN-Habitat's Global Urban Observatory

WHO Global Health Observatory

https://www.who.int/data/gho/

The GHO data repository is WHO's gateway to health-related statistics for its 194 Member States. It provides access to over 1000 indicators on priority health topics including mortality and burden of diseases, the Millennium Development Goals (child nutrition, child health, maternal and reproductive health, immunization, HIV/AIDS, tuberculosis, malaria, neglected diseases, water and sanitation), non-communicable diseases and risk factors, epidemic-prone diseases, health systems, environmental health, violence and injuries, equity among others.

Social Indicators database

https://unstats.un.org/unsd/demographic/products/socind/

The Social Indicators database includes information relating to population, health, housing, education, and work.

WHO Mental Health

https://www.who.int/health-topics/mental-health

Data from the World Health Organization (WHO) that pertains to mental health. It includes the suicide rate, and several other statistics relating to mental health treatment.

FAO

https://www.fao.org/faostat/en/#data

The Food and Agriculture database (FAO) provides information about agricultural production.

FAO Food Price Monitoring and Analysis Tool

https://fpma.fao.org/giews/fpmat4/#/dashboard/home

The United Nations Food and Agriculture Organization provides information on agriculture and livestock prices around the world. For example, you can find information on the price of wheat in Sao Paulo, Brazil.

United Nations Conference on Trade and Development

https://unctadstat.unctad.org/EN/Pci.html

provides information on PCI (Productive Capacities Index). PCI includes human capital, energy, transport, etc.

The MDG (Millennium Goal Indicators)

https://unstats.un.org/wiki/display/mdgs

The archive of the official MDG Indicators website. This site will present the official data, definitions, methodologies and sources for more than 60 indicators to measure progress towards the Millennium Development Goals.

UN Dag Hammarskjöld Library

https://www.un.org/library

- Library services (reference and research assistance, training courses and resources)
- Library resources (information about various databases and journals we subscribe to)
- Links to useful research tools for UN documentation

- Single search box to discover and access UN materials in the UN Digital Library, as well as books in the library collections, e-books, e-journals, journal articles, and open access papers
- Access to our popular Ask DAG knowledge base and our research guides
- UN Member States on the Record
- UN Depository Library Programme
- Library News blog

UN SDG: Learn

https://statistics.unsdglearn.org/learning/

Learning tools/syllabus on various statistics. Data and statistics explained.

- Economic Statistics
- Demographic and social statistics
- Environment and multi-domain statistics
- Strategic and managerial issues
- Methodology and statistical processes

World Bank

World Development Indicators

https://datacatalog.worldbank.org/search/dataset/0037712/World-Development-Indicators

The World Development Indicators (WDI) is the primary World Bank collection of development indicators, compiled from officially-recognized international sources. It presents the most current and accurate global development data available, and includes national, regional and global estimates.

World Bank Open Data

https://data.worldbank.org/

Open Data Catalog

http://datacatalog.worldbank.org/

Provides a listing of available World Bank datasets, including databases, pre-formatted tables, reports, and other resources.

DataBank

http://databank.worldbank.org/data/home.aspx

An analysis and visualisation tool that contains collections of time series data on a variety of topics.

Microdata Library

http://microdata.worldbank.org/

Provides access to data collected through sample surveys of households, business establishments or other facilities.

Atlas of Sustainable Development Goals

https://datatopics.worldbank.org/sdgatlas/

Guides readers through the Sustainable Development Goals using interactive storytelling and innovative data visualizations.

International Debt Statistics

https://datatopics.worldbank.org/debt

Provides access to comprehensive annual statistics on external debt stocks and flows for 120 developing countries.

World Bank Group International Debt Statistics

https://openknowledge.worldbank.org/handle/10986/34588?deliveryName=DM91887

The World Bank Group has compiled an extensive database on International Debt Statistics.

International Comparison Program

https://www.worldbank.org/en/programs/icp

Explore purchasing power parities (PPPs), price levels, economic data and the methodology behind the world's largest statistical partnership.

Open Finances

https://finances.worldbank.org/

Explore raw data about the World Bank Group's finances, including disbursements and management of global funds.

Projects & Operations

https://projects.worldbank.org/

Provides access to basic information on all of the World Bank's lending projects from 1947 to the present.

Open Data Toolkit

https://opendatatoolkit.worldbank.org/en/data/opendatatoolkit/home

Provides an understanding of Open Data and how to get "up to speed" in planning and implementing an open data program.

Living Standards Measurement Study

http://www.worldbank.org/lsms

Supports countries in conducting multi-topic household surveys to generate high-quality data, improve survey methods and build capacity.

Global Consumption Database

http://datatopics.worldbank.org/consumption/

A one-stop source of data on household consumption patterns in developing countries.

Statistical Performance Indicators (SPI)

http://www.worldbank.org/spi

The indicators measure statistical performance across 174 countries. These are the data behind the World Development Report. The indicators are grouped into five dimensions, which capture whether foundations such as financing, skills, and governance needed for a strong statistical system are in place. Under each dimension is a set of indicators to measure performance providing a time series extending at least from 2016 to 2019 in all cases, with some indicators going back to 2004.

Global Data Regulation Survey

https://microdata.worldbank.org/index.php/catalog/3866

The Global Data Regulation diagnostic is a comprehensive assessment of laws and regulations on data governance. It covers both the enabler and safeguard regulatory practices in 80 countries. The questionnaire comprises 37 questions designed to determine if a country has adopted good regulatory practice on data governance.

Data Governance Indicators

https://databank.worldbank.org/source/worldwide-governance-indicators

Aggregate and individual governance indicators for six dimensions of governance: Voice and Accountability; Political Stability and Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption.

OTHER INTERNATIONAL AND REGIONAL ORGANIZATIONS

ECE - Statistical Database

http://w3.unece.org/pxweb/Dialog/

Statistical database of ECE, the Economic and Social Commission for Europe. Includes country overviews and statistics on economics, forestry, gender, transport, and other areas.

ECLAC - CEPALSTAT

https://statistics.cepal.org/portal/cepalstat/index.html?lang=en

Statistical database of ECLAC, the Economic and Social Commission for Latin America and the Caribbean. Includes social, demographic, economic, environmental, and other statistics.

IMF - eLibrary – Data

https://data.imf.org/

This database gives access to international financial data and statistics collected by the International Monetary Fund (IMF), the International Financial Statistics (IFS) and the regional economic outlook.

G20 Data Gaps Initiative

https://www.imf.org/en/News/Seminars/Conferences/g20-data-gaps-initiative

A Group of 20 (G-20) initiative to ensure regular collection and dissemination of reliable and timely statistics for policy use. Areas covered include: (i) climate change; (ii) household distributional information; (iii) Fintech and financial inclusion; and (iv) access to private sources of data and administrative data, and data sharing.

World Economic Outlook

https://www.imf.org/en/Publications/WEO/weo-database/2024/October

The World Economic Outlook database shows macroeconomic trends including GDP, inflation rate, employment, among others.

WIPO IP Portal

https://ipportal.wipo.int/

WIPO IP Portal includes the World Intellectual Property Organization's global collections of searchable IP data with resources for patents, brands, domain name, designs, statistics, classifications, and standards. Includes WIPO-Lex, a collection of laws, treaties and judgements from WIPO member states.

Global Design Database

https://www.wipo.int/designdb/en/index.jsp

The World Intellectual Property Organization (WIPO) is the world's most comprehensive source of data on the intellectual property (IP) system, as well as of empirical studies, reports and factual information on IP. Whether you are seeking statistical, legal or technical information, this page is a gateway to our unique collections of resources and reference material. We make all our publications and data collections freely available online.

WTO Statistics Database

https://stats.wto.org

The World Trade Organization statistics database allows for retrieval of statistical

information through four presentations: Trade Profiles, Tariff Profiles, Services Profiles and the Time Series section.

Global Revenue Statistics

https://stats.oecd.org/Index.aspx?DataSetCode=RS_GBL

The Global Revenue Statistics database includes economic data for each country.

OTHER

World Inequality Database

https://wid.world/

Reference data to track economic inequality at the global level, within countries and over time. Based on the systematic combination of national accounts, survey and fiscal data. Open access data, easy-to-use visualization tools and transparent methodology for researchers, civil society, business and political communities. More than 100 top-level researchers involved, covering 70 countries over 5 continents. Entirely funded by public and non-profit actors.

Statista

https://en.statista.com/

Information on industries, companies, consumers, trends, countries, politics, and society covering the latest and most important issues in a condensed format. Chart of the Day (https://www.statista.com/chartoftheday/)

Nation Master

https://www.nationmaster.com/

Database provides 50,000 stats on industries including finance, manufacturing, services, and many other industries.

Global Climate Risk Index

https://www.germanwatch.org/en/cri

Provides analysis on which countries and regions have been most affected by climate change.

Sedac (Socioeconomic Data and Applications Center)

https://sedac.ciesin.columbia.edu/

provides information about food security, the environment and several other topics.

World Population Prospects

https://knoema.com/UNWPP2022/world-population-prospects-2022

This database analyzes population growth in different countries and regions. requires sign in

Inclusive Development Index

https://knoema.com/WEFTIDI2018Jan/inclusive-development-index

This database analyzes economic growth requires sign in and development with a variety of different measures and tools.

The Democracy Index 2022

https://www.eiu.com/n/wp-content/uploads/2023/02/Democracy-Index-2022_FV2.pdf

Gives an overview of how governments are functioning around the world. It assess

how democratic or how authoritarian certain governments are.

Global Dietary Database

https://www.globaldietarydatabase.org/our-data/data-visualizations/country-comparisons

The Global Dietary database has information on the differences in diet between countries. It shows which type of foods certain countries eat a lot of or not so much.

Our World in Data

https://ourworldindata.org/

Research and data to make progress against the world's largest problems. 3154 charts across 297 topics. All free: open access and open source

Our World in Data— Global Food Explorer

https://ourworldindata.org/explorers/global-food

The global food system from field to plate, for all countries in the world.

SDG Tracker

https://sdg-tracker.org/

Measuring progress towards the Sustainable Development Goals; SDG Tracker presents data across all available indicators from the Our World in Data (https://ourworldindata.org/) database, using official statistics from the UN and other international organizations. 232 indicators. Definitions of indicators are here: https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20refinement_Eng.pdf

Global Edge

https://globaledge.msu.edu/global-resources/statistical-data-sources

An inventory of global statistical data sources.

Statistical Review of World Energy

https://www.energyinst.org/statistical-review

The Energy Institute Statistical Review of World Energy™ analyses data on world energy markets from the prior year.

Energy Statistics Data Browser

https://www.iea.org/data-and-statistics

International Energy Agency statistics with charts and tables on 16 energy topics for over 170 countries and regions.

Center for International Earth Science Information Network (CIESIN)

http://www.ciesin.org/

Center for International Earth Science Information Network (CIESIN) is an organization dedicated to making information available to researchers, policy makers, and the general public. The site focuses on the changing relationship between human beings and the environment. It includes their own research and statistics, as well as a gateway to some of World Bank's data.

Global Data Lab

https://globaldatalab.org/sdgs

Subnational SDG Dashboard (Beta) Data, Maps, etc.

Global Indicators Database

https://www.pewresearch.org/global/database/

Pew Research Center. Contains data from nearly 600,000 interviews in 64 countries on subjects ranging from people's assessments of their own lives to their views about the current state of the world and important issues of the day.

NASA Data Pathfinders

https://earthdata.nasa.gov/learn/pathfinders

Direct links to commonly used NASA Earth science datasets, from greenhouse gases to sea level change.

Global Hunger Index data

https://www.globalhungerindex.org/download/all.html

The Global Hunger Index is a peer-reviewed annual report, jointly published by Concern Worldwide and Welthungerhilfe, designed to comprehensively measure and track hunger at the global, regional, and country levels. The aim of the GHI is to trigger action to reduce hunger around the world.

Earth Dashboard

https://earthdash.org/

The Earth Dashboard presents a multifaceted perspective on the key indicators of the world. It does this through a series of real-time meters, gauges, trends, maps, maps in time series, viability thermometers, and alarms (among other data visualization techniques) that transform global statistical information into creative information visualizations.

Worldometers

https://www.worldometers.info

Worldometer has the the goal of making world statistics available in a thought-provoking and time relevant format.

WorldClock

https://www.timeanddate.com/worldclock/

Shows times and dates around the world.

Drawdown

https://www.drawdown.org/

Project Drawdown® is a nonprofit organization and coalition of scholars, scientists, entrepreneurs, and advocates from across the globe that is mapping, measuring, modeling, and communicating about a collective array of substantive solutions to global warming, with the goal of reaching drawdown. Drawdown is the point in time when the concentration of greenhouse gases in the Earth's atmosphere begins to decline on a year-to-year basis. Project Drawdown has developed realistic, solution-specific models, technical assessments, and policy memos projecting the financial and climate impacts of existing solutions deployed at scale over the next thirty years.

Fragile States Index

https://fragilestatesindex.org/

The Fragile States Index (FSI) produced by The Fund for Peace (FFP), is a critical tool in highlighting not only the normal pressures that all states experience, but also in identifying when those pressures are outweighing a states' capacity to manage those pressures. By highlighting pertinent vulnerabilities which contribute to the risk of state fragility, the Index — and the social

science framework and the data analysis tools upon which it is built — makes political risk assessment and early warning of conflict accessible to policy-makers and the public at large.

Global Infrastructure Hub

https://pipeline.gihub.org/

The Global Infrastructure Hub is the only organization dedicated solely to infrastructure in both developed and emerging markets. We focus on collaborating with governments, the private sector, multilateral development banks and other international organizations to promote the enabling environment that will allow the identification and development of infrastructure projects that are high-quality, resilient, sustainable and needed, in a rapidly-evolving world.

Global Slavery Index

https://www.walkfree.org/global-slavery-index/

The Global Slavery Index provides a country by country ranking of the number of people in modern slavery, as well as an analysis of the actions governments are taking to respond, and the factors that make people vulnerable. This year, so that we might better understand the problem, we have also included an analysis of trade flows and data on state imposed forced labour in North Korea, risk factors in the fishing industry, and the prevalence of forced labour in the cocoa sector.

Global Wind Atlas

https://globalwindatlas.info/

The Global Wind Atlas is a free, web-based application developed to help policymakers and investors identify potential high-wind areas for wind power generation virtually anywhere in the world, and perform preliminary calculations. This new tool facilitates online queries and provides freely downloadable datasets based on the latest input data and modeling methodologies. Users can additionally download high-resolution maps showing global, regional, and country wind resource potential in the Downloads section. Information on the datasets and methodology used to create the Global Wind Atlas can be found in the Methodology and Datasets sections.

ISRIC Soil Geographic Databases

https://www.isric.org/explore/soil-geographic-databases

Providing information on the soils of the world is an enormous task and continuing challenge for ISRIC — World Soil information. ISRIC collects, harmonizes and publishes global soil geographic information, whereas many national, regional, local and NGO organizations provide soil information specific to their area and according to their procedures and standards.

State of Democracy

https://www.eiu.com/n/campaigns/democracy-index-2022/

The report published by Economist contains information on the state of democracy around the world. The report identifies strengths and weaknesses of different countries' democracies.

Economist Intelligence Unit (not free)

Worldwide Cost of Living 2023

https://store.eiu.com/product/worldwide-cost-of-living-2023/

Assesses current and past trends impacting cost of living globally. The report draws upon a comprehensive data set of more than 200 products and services covering 173 cities worldwide.

Country Forecast

https://store.eiu.com/product/country-forecast

Understand the economic and political developments shaping the business environment in a country for the next five years. Covering 82 countries, each report is updated monthly.

Country Report

https://store.eiu.com/product/country-report

Examines and explains the important political and economic trends in a country. Each report contains in-depth and ongoing analysis and forecasts of political, policy and economic conditions in a country.

Country Risk Service

https://mkto-ab220141.com/NzUzLVJJUS00MzgAAAGBd_s38Fq-QCS4N5iHXNWmtSeAr5BsJXm0s8Itjk3CHiiVFAsxYo3Tw3fpuFy_fUBuehEJoyY=

Receive trusted sovereign risk ratings and analysis for 131 countries. Includes short and medium-term economic and policy forecasts.

Country Data

https://store.eiu.com/product/countrydata

A comprehensive country-by-country data set containing more than 300 key economic indicators for a country, with data ranging from 1980 to 2050.

United States Government

CIA World Factbook

https://www.cia.gov/the-world-factbook/

The World Factbook provides basic intelligence on the history, people, government, economy, energy, geography, environment, communications, transportation, military, terrorism, and transnational issues for 266 world entities.

The CIA (Central Intelligence Agency)

https://www.cia.gov/resources/cia-maps/

provides informative maps across 95 locations all over the world.

United States Census Bureau: World Population Estimates and Projections

https://www.census.gov/programs-surveys/international-programs/about/idb.html

With the international database, you can view demographic measures of over 200 countries and areas with populations of 5,000 or more, and for

thousands of subnational areas (equivalent to U.S. states, counties, and townships in other countries).

United States Department of Agriculture: International Macroeconomic Data Set

https://catalog.data.gov/dataset/international-macroeconomic-data-set

The International Macroeconomic Data Set provides data from 1969 through 2030 for real (adjusted for inflation) gross domestic product (GDP), population, real exchange rates, and other variables for the 190 countries and 34 regions that are most important for U.S. agricultural trade.

World Agricultural Production

https://catalog.data.gov/dataset/world-agricultural-production

Monthly report on crop acreage, yield and production in major countries worldwide.

IPCC Socio-Economic Baseline Dataset

https://catalog.data.gov/dataset/ipcc-socio-economic-baseline-dataset

The Intergovernmental Panel on Climate Change (IPCC) Socio-Economic Baseline Dataset consists of population, human development, economic, water resources, land cover, land use, agriculture, food, energy and biodiversity data.

DARPA Open Catalog

https://www.darpa.mil/opencatalog

The DARPA Open Catalog contains citations of DARPA-sponsored software, peer-reviewed publications, and data. DARPA sponsors fundamental and applied research in a variety of areas that may lead to experimental results and reusable technology designed to benefit multiple government domains. DARPA has an open strategy to help increase the impact of government investments, as well as an interest in building communities around government-funded research.

Minerals Commodity Summaries

https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

Published on an annual basis by the United States Geological Survey, this report is the earliest Government publication to furnish estimates covering nonfuel mineral industry data. Data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for over 90 individual minerals and materials.

Data analysis tools

Facets: Know Your Data.

https://pair-code.github.io/facets

"Better data leads to better models" is the motto of Facets, a toolkit for "understanding and analyzing machine learning datasets." Facets offers two powerful data visualization tools. The first, Overview, gives users a quick visual analysis of the distribution of values across the features of one or more datasets. Overview provides users with summary statistics that give the general shape of each feature of their dataset and may help identify issues like unexpected values, missing values for a large number of observations, training/serving skew, and train/test/validation skew. The second tool, Dive, is an interactive interface for exploring large numbers of data points at once. Dive visualizes the relationships between data points across all different features of a dataset and allows a data point to be bucketed in multiple dimensions. The tool can help users identify classifier failure, systematic errors, and potential new signals for ranking. Facets is an open-source software toolkit developed by the People + AI Research (PAIR) team at Google Research. [HCL]

SDG Tracker

https://sdg-tracker.org/

SDG Tracker measures progress towards the Sustainable Development Goals; SDG Tracker presents data across all available indicators from the Our World in Data database (https://ourworldindata.org/), using official statistics from the UN and other international organizations. 232 indicators. Definitions of Indicators are included.

Gapminder

https://www.gapminder.org

Gapminder provides data visualization of UN and other reliable data sources to fight devastating misconceptions and promote a fact-based worldview everyone can understand.

APPENDIX 3 Solutions Libraries

Global Solutions Lab

https://designsciencelab.com/global-solutions-database/

Global Solutions Database of solutions to global problems and achieving the SDGs.

Project Drawdown

https://drawdown.org/solutions/table-of-solutions

Drawdown Solutions Library of climate change related strategies.

UNDP

https://www.undp.org/tag/solutions-mapping

Accelerator Labs Network

Engineers for Change

https://www.engineeringforchange.org/solutions/products

The Solutions Library is an open-access and curated knowledge database showcasing technology-driven solutions addressing sustainable development challenges in resource-constrained settings.

Systems Change Lab

https://systemschangelab.org/shifts

Systems Change Lab identifies more than 70 critical changes – what they call shifts – that can help deliver systemwide transformations. These shifts are changes within a system, and when multiple shifts work together, they can spur transformational change.

Solutions Story Tracker

https://www.solutionsjournalism.org/storytracker

Curated database of reporting on responses to social problems: 12,900 stories produced by 6,000 journalists and 1,600 news outlets from 187 countries, growing every day.

UN SDSN Global Climate Hub

https://unsdsn.globalclimatehub.org

Provides science-based recommendations for combating climate crisis and preventing further deterioration. Uses extensive data, knowledge, and technologies provided by experts in various fields to implement country-specific action plans. Nine focus areas of the SDSN GCH represent the stages that a country should go though in order to achieve the design and implementation of detailed climate neutrality and climate resilience pathways.

Climate Solutions that Work

https://www.worldbank.org/en/news/immersive-story/2023/12/01/climate-solutions-that-work

The World Bank is the largest multilateral funder of climate investments in developing countries ($38.6 billion in 2023). This site identifies 'gamechangers'– climate investments that are

radically transforming sectors and building more resilient communities.

Evidence Bank (Health and net-zero solutions)

https://climatehealthevidence.org/case-studies

Brings together evidence on climate mitigation actions with the largest potential health benefits across sectors. Evidence bank highlights case studies of implemented solutions with measured climate and health benefits.

UpLink Innovation Ecosystem

https://uplink.weforum.org/uplink/s/

(Open innovation platform of the World Economic Forum, Innovation challenges) Entrepreneurs with innovative solutions.

weADAPT

https://weadapt.org

Up-to-date, dynamic space to accelerate urgently needed action on climate change adaptations.

Ashoka Changemakers/Green Changemakers Challenge

https://www.changemakers.com/en/challenge/green-changemakers

McKinsey & Company Removing carbon, one solution at a time.

https://www.mckinsey.com/featured-insights/sustainable-inclusive-growth/charts/removing-carbon-one-solution-at-a-time

UN DESA UN System SDG Implementation

https://sdgs.un.org/partnerships/action-networks/acceleration-actions

SDG Acceleration Actions accelerate SDG implementation by governments and any other non-state actors - individually or in partnership.

AI for Sustainable Development Goals (AI4SDGs) Think Tank

https://www.ai-for-sdgs.academy/

A global collection of AI projects and proposals that impacts UN Sustainable Development Goals, both positively and negatively.

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"We are called to be the architects of the future, not its victims."

—Buckminster Fuller