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Systems Thinking

Short Video in a series: Systems Thinking (Dr. Linda Vanasupa)

https://www.youtube.com/watch?v=TA7GGZPzSoE

https://www.youtube.com/watch?v=lN7rpaRSN9w

https://www.youtube.com/watch?v=kUAf1w_x6y4

https://www.youtube.com/watch?v=6kon01lNb5M

https://www.youtube.com/watch?v=jOrE66l9fyw (Note: the D. Meadows document cited at the beginning of this video is set forth below; *Twelve Leverage Points To Intervene in a System*, by Donella Meadows (1997)

One of the best Systems Thinking Sites:
http://www.donellameadows.org/

What is a system?
It is a set of interacting and interdependent components forming an integrated whole.

If I want to study "systems", what disciplines / keywords should I start with?

Systems Thinking

The process of understanding how things influence one another within a whole. In nature, systems thinking examples include ecosystems in which various elements such as air, water, movement, plants, and animals work together to survive or perish. In organizations, systems consist of people, structures, and processes that work together to make an organization healthy or unhealthy.

Systems Dynamics

A methodology and mathematical modeling technique for framing, understanding, and discussing complex issues and problems. Originally developed in the 1950s to help corporate managers improve their understanding of industrial processes, system dynamics is currently being used throughout the public and private sector for policy analysis and design.

Systems Theory

The interdisciplinary study of systems in general, with the goal of elucidating principles that can be applied to all types of systems at all nesting levels in all fields of research. In this context the word *systems* is used to refer specifically to self-regulating systems, i.e. that are self-correcting through feedback. Self-regulating systems are found in nature, including the physiological systems of our body, in local and global ecosystems, and in climate - and in human learning and social processes.

Systems Science

Is an interdisciplinary field of science that studies the nature of complex systems in nature, society, and science. It aims to develop interdisciplinary foundations, which are applicable in a variety of areas, such as engineering, biology, medicine and social sciences.

Cybernetics

The interdisciplinary study of the structure of regulatory systems. It is equally applicable to physical and social (that is, language-based) systems.

Complexity Science

Is the study of the behaviors of systems that are considered fundamentally complex. This often involves equations from which complex system models are developed generally derive from statistical physics, information theory and non-linear dynamics.

Twelve Leverage Points To Intervene in a System, by Donella Meadows (1997) Wikipedia

The following are in **increasing order of effectiveness**.

12. Constants, parameters, numbers (such as subsidies, taxes, standards)

Parameters are points of lowest leverage effects. Though they are the most clearly perceived among all leverages, they rarely change behaviors and therefore have little long-term effect.

11. The size of buffers and other stabilizing stocks, relative to their flows

A buffer's[1] ability to stabilize a system is important when the stock[2] amount is much higher than the potential amount of inflows or outflows. In the lake, the water is the buffer: if there's a lot more of it than inflow/outflow, the system stays stable.

10. Structure of material stocks and flows (such as transport network, population age structures)

A system's structure may have enormous effect on operations, but may be difficult or prohibitively expensive to change. Fluctuations, limitations, and bottlenecks may be easier to address.

9. Length of delays, relative to the rate of system changes

Information received too quickly or too late can cause over- or under-reaction, even oscillations.

8. Strength of negative feedback loops, relative to the effect they are trying to correct against

A negative feedback[3] loop slows down a process, tending to promote stability. The loop will keep the stock near the goal, thanks to parameters, accuracy and speed of information feedback, and size of correcting flows.

7. Gain around driving positive feedback loops

A positive feedback[4] loop speeds up a process. Meadows indicates that in most cases, it is preferable to slow down a positive loop, rather than speeding up a negative one.

6. Structure of information flow (who does and does not have access to what kinds of information)

Information flow is neither a parameter, nor a reinforcing or slowing loop, but a loop that delivers new information. It is cheaper and easier than changing structure.

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[1] A buffer is a temporary storage.
[2] A stock is a part of a system where accumulation occurs.
[3] Negative feedback does not mean “bad”. It means feedback that slows the rate a process.
[4] Positive feedback does not mean “good”. It means feedback that increases the rate of a process.

5. Rules of the system (such as incentives, punishment, constraints)

Pay attention to rules, and to who makes them.

4. Power to add, change, evolve, or self-organize system structure

Self-organization describes a system's ability to change itself by creating new structures, adding new negative and positive feedback loops, promoting new information flows, or making new rules.

3. Goal of the system

Changes every item listed above: parameters, feedback loops, information and self-organization.

2. Mindset or paradigm that the system — its goals, structure, rules, delays, parameters — arises out of

A society paradigm is an idea, an unstated assumption that everyone shares, thoughts, or states of thoughts that are sources of systems. Paradigms are very hard to change, but there are no limits to paradigm change. Meadows indicates paradigms might be changed by repeatedly and consistently pointing out anomalies and failures to those with open minds.

1. Power to transcend paradigms

Transcending paradigms may go beyond challenging fundamental assumptions, into the realm of changing the values and priorities that lead to the assumptions, and being able to choose among value sets at will.

An important thing systems thinking helps avoid:

Unintended Consequences

Outcomes that are not the outcomes intended by an intended action. It is a problem when that outcome is negative.

A few classic examples:

The Prohibition Amendment: Unintended consequence = creation of modern organized crime.

War on Drugs: Unintended consequences = higher costs – higher risk and profit – increased street violence.

"Three Strikes Your Out" = Prior offenders have juveniles hold supply – some juveniles make money selling some of that supply – drugs and weapons move into schools.

“Blow Back” CIA term. Example; fundamentalist Islamic guerilla groups organized and outfitted to proxy fight against Soviet Union forces during cold war. After cold war they use their abilities to try and counter American interests.

Rapid Climate Change

Climate Change Strategy Tool Box

Community Resiliency: Rapid Climate Strategy for Business

Methane digesters and generator building, Green Valley Dairy, Shawano County J. Moynihan

Rapid Climate Change Strategy is the overall approach by a business to adapt to the current climate change. Since the current change is scientifically linked to the use of fossil fuels, it is also the planning & implementation of a strategy for reducing energy costs.

A strategy comprises an integrated approach to dealing with the risks ***and*** opportunities of:

- Regulation and taxation
- Liability
- Changes in weather (physical risks)
- Technological innovation
- Consumer and citizen attitudes and demands
- Carbon trading, sequestration &set asides

Other terms include: Climate Change Strategy and Carbon Strategy

Why is a climate change strategy important?
Our production and transport systems are primarily reliant upon the combustion of fossil fuels. That combustion is the cause for the current rapid climate change process. Also, fossil fuels are finite. Oil

according to industry projections has entered its “peaking” period, (Engineering Executives Forum 2006 – Engineering Sustainability in the Global Enterprise, UW Madison (2006)).
This situation points to rising fossil fuel energy costs, all other things being equal, over the short long term. To address the situation, businesses need to integrate climate change and how to deal with it into business strategy and planning.

Method for addressing a Rapid Climate Change Strategy

Any business strategy must account for:
Direct CO2 emissions
And
Indirect or embedded CO2 emissions

Direct emissions are the CO2 that a business puts in the atmosphere via combustion in generating power, or in production processes.

Indirect or embedded emissions are the CO2 releases that are part of a business:

- Supply chain
- Transport
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- Customer use
- Product disposal
- Operations

Whole Milk
Serving Size 8 fl oz (240mL)
Servings Per Container 2

Amount Per Serving
Calories 150 Calories from Fat 70

	% Daily Value*
Total Fat 8g	12%
Saturated Fat 5g	25%
Cholesterol 35mg	12%
Sodium 125mg	5%
Total Carbohydrate 12g	4%
Dietary Fiber 0g	0%
Sugars 11g	

CARBON: 1 kg

Vitamin A 6% • Vitamin C 4%
Calcium 30% • Iron 0% • Vitamin D 25%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

The side of the British milk carton to the right includes a carbon figure in kilograms. It tells the shopper about that product’s embedded CO2 emission, i.e. the total amount of CO2 emitted to make the product and get it to

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“GHG” means Green House Gas.

Table: Plan Process & Elements

The following table lays out the steps and elements of a planning process.

The “sub-processes” are listed along the left side rows.

- Governance: Decision making and guiding the organization.

- Determining Carbon Foot Print/GHG Inventory: Determining the carbon intensity of the businesses' operations.
- Risks: Determination and analysis of risks to the business from rapid climate change.
- Opportunities: Determination of what opportunities may for the business from rapid climate change, or from its adaptation and mitigation actions.
- Plan Targets: The future benchmarks the business will work to achieve.
- Management: The actions and time lines for achieving the plan targets.
- Measurement & Reporting: Getting the data you need for the businesses' progress, and also for voluntary and future regulatory reporting.

Along the top columns are two broad phases, and "considerations".

- Initial Steps: Situational analysis, study, and determining necessary outputs.
- Plan Elements: The "outline" for the businesses' plan, to fleshed out in the plan.

The reference section after table provides a Wisconsin company example, and resources grouped by sub-process.

Process	Initial Steps	Plan Elements	Considerations
Governance	· Who is responsible within the company? · The board or committee with overall responsibility for climate matters? · Who is responsible in each department or division? · Include climate strategy in management and employee training.	· Responsible parties	· Initiate change before the threats are too severe. · Is there a business case for the change, i.e. is justified in terms of costs and benefits? · Incentives/Bonus structure as related to climate matters?
Determining Your Carbon Foot Print (GHG Inventory)	Pick a baseline year. Quantify your "Carbon Footprint". Measure, benchmark and inventory. Use carbon accounting tools.	· Baseline year · Inventory method · Inventory results · Estimation of emissions · Calculation method	The tool called Life Cycle Assessment aka Life Cycle can be used to figure product/service embedded emissions.
Risks	Regulation and taxation Liability Changes in weather (physical risks) Technological innovation Consumer and citizen attitudes and demands Carbon trading, sequestration &set asides	· Tax effects · Regulatory effects · Physical risk (self, suppliers, customers) · Technological competitiveness · Customer attitudes and demands · Carbon credit needs · Sequestration and offset needs	How can risks for customers be used for new products or services?
Opportunities	Regulation and taxation	· Tax effects · Regulatory effects	As your knowledge about climate change increases,

	Liability Changes in weather (physical risks) Technological innovation Consumer and citizen attitudes and demands Carbon trading, sequestration &set asides	· Physical · New technology applications · Customer attitudes and demands · Carbon Market Income Opportunities · New products/services · Patents/intellectual property	leverage it to develop new products and services. Build internal knowledge, skill and capacity within your company, instead of outside of it. Focus on the needs of key customers. Pay attention to "green" early adopters [lead customers]
Plan Targets		· Your GHG reduction targets · Relationship between cost of future emissions and capital planning · Estimation of income from carbon market activities	As your process matures, you may begin to add targets such as new revenue streams, product/service roll-outs, etc.
Management	Linking production or process to emissions direct and/or indirect/embedded Cost of energy consumption Energy efficiency activities Renewable energy options	· Energy cost · Renewables · Amount in fossil fuels · Amount in electric · Investments made · Investments required · Savings achieved · Estimated future savings <u>Action plan with time table</u>	Allow sufficient time, resources for change, especially in regard to core or essential areas. After you deal with your own facility(s) and processes it is important to then start figuring in supply chain, product/service use, disposal. Figure out how to transition from carbon intensive products and services that heavily contribute to your profits Buy stock, supplies, parts, and feedstock as much as you can locally.
Measurement & Reporting	Development of evaluation criteria and methods.	· Who Reviews Progress? · Review method(s)	What is measured is managed. External verification or auditing?

Community Resiliency: Rapid Climate Change Strategy for Local Government

Leadership Shawano County session **Jay Moynihan**

Other terms include: Climate Change Strategy, Carbon Strategy, Climate Change Preparedness

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Rapid Climate Change (RCC) Strategy is the overall approach by a government or organization to adapt to the current rapid onset of climatic change locally and globally. Since the current climate change is scientifically linked to the use of fossil fuels, climate change strategy encompasses planning & implementing of a strategy for reduce energy use and costs and shift to renewable energy sources. energy.

Climate change encompasses significant change in average measures of climate, including temperature, precipitation, or wind. The term climate change is often used interchangeably with the term global warming.
This can be misleading. Global warming is the average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere. This contributes to changes in global and regional climate patterns.
The Intergovernmental Panel on Climate Change (IPCC) reports to the world's governments on the research on climate change. It has 2,500 scientific contributors, and they incorporate the work of thousands of other scientists. According to the IPCC the rapid climate change currently occurring is the result of human activity, primarily related to the combustion of fossil fuels.

For a local government, a RCC Strategy is comprised of three broad areas:

1. Assessing Vulnerability
What are the negative effects form rapid climate change in your territory for your residents, their communities and businesses?
2. Mitigation

What actions can be taken to the magnitude and severity of rapid climate change on your residents.

3. Adaptation

How does implementation proceed so that residents adjust to the changing conditions and the local government continues to provides quality services to citizens.

These need to approached with an eye fixed firmly on the cost over time to taxpayers. But "cost" is a broader concept than taxes. What is the true or whole cost to the tax payer? A local government may experience short term cost savings from implementing a strategy. But more importantly, the planning and implementation must help build the long term economic, social, and environmental progress of your residents.

Probable impacts of climate change in Wisconsin up to 2050 include:

- Increase in average annual temperature by 2050 of 2.5◦ C (4.5◦ F).
- Length of Winter season shortening, hence earlier onset of Spring
- Decreasing average annual snow pack
- More thaw periods during winter
- More winter precipitation in form of ice
- Wind storm increase
- Tornadoes increase in frequency and/or strength
- Warm season precipitation may in short term increase, then markedly decrease before 2050.
- Increasing daytime evaporation rates.
- Warm season precipitation occurring in heavier, shorter events.
- Lakes and ponds likely to decrease in depth.
- Rivers likely to decrease in depth except during flood events.
- Water bodies likely to be progressively warmer.
- Increasing eutrophication
- Higher irrigation demand
- By 2050, conditions should favor species adapted to areas such as Southern Missouri/Northern Arkansas (not counting its local elevation).
- New "mobile" species appearing from south, and new parasites, hyper-parasites and pathogens.
- Noticeable migration in of "new" winged insect species.
- Potentially collapsed ecosystem areas due to keystone specie failures, or cascade events (2050 & later).
- Traditional migratory bird numbers likely to continue decreasing significantly.
- Development pressure should increase significantly, especially with likely human migration towards Great Lakes from drying southern half of U.S.

Why is a RCC strategy important for managing energy costs?
Our production and transportation systems are primarily reliant upon the combustion of fossil fuels. That combustion is the cause for the current rapid climate change process. Also, fossil fuels are finite. Oil according to industry projections has entered its "peaking" period. (Engineering Executives Forum 2006 – Engineering Sustainability in the Global Enterprise, UW Madison (2006))
This situation points to rising fossil fuel energy costs, all other things being equal, over the long term. To address the situation, governments need to integrate climate change and how to deal with it into their policies, strategy and planning.

Planning for rapid climate change is simply part of good government. It is part of the duty of local officials and staff to further the safety & prosperity of your residents.

King County Leads the Way
Fortunately, a county government has already developed a comprehensive handbook on how to plan and implement for rapid climate change at the local government level. That handbook can be freely downloaded, the link is in the reference section of this writing.

The King County process was driven by it's Executive Ron Sims. Mr. Sims was picked in 2008 by American City & County Magazine as County Leader of the Year. King County's seat of government is Seattle. Located on Puget Sound in Washington State, and covering 2,134 square miles, King County is nearly twice as large as the average county in the United States. With more than 1.8 million people, it also ranks as the 13th most populous county in the nation. The County's gateway site about climate change is http://www.kingcounty.gov/exec/globalwarming.aspx

The King County Process
The table sets out the steps set out in detail in the link in the reference section, "Preparing for Climate Change: A Guidebook for Local, Regional and State Governments.Prepared by the King County, Washington government."

1. Review of science about rapid climate change in Wisconsin.	The links in the reference section entitled "Information for Situational Analysis of Vulnerability".
2. Scope the rapid climate change impacts to your major sectors.	The links in the reference section entitled "Information for Situational Analysis of Vulnerability".
3. Obtain "buy-in" from the elected officials and employees.	
4. Develop a Preparedness Message for sector leaders and citizens.	
5. Build your climate rapid change preparedness Team	This is the group that will develop your plan. Remember that in addition to government staff, include community and sector business members, and educators.
6. Identify planning areas relevant to rapid climate change.	Scope your departments and business sectors.
7. Conduct a rapid climate change vulnerability assessment.	Remember to review the GHG Protocol materials, linked in the Reference section below. They can be a big help in this.
8. Conduct a rapid climate change risk assessment.	
9. Set preparedness goals.	
10. Develop Preparedness Plan.	
11. Implementation.	
12. Management, evaluation, plan updating.	

Note: If your local government operates an electric or gas utility, please also consult our materials on Rapid Climate Change Strategy for Business.