APPROACHES FOR PLANNING AND IMPLEMENTING SUSTAINABLE ENERGY GROWTH IN A COMPLEX WORLD

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There is much support globally for sustainable energy development. Viewpoints and rationales vary widely, but they sum up to a common goal.
Leaders / stakeholders seek comfort with expected outcomes

New tools and techniques are needed
Current situation: Energy supply dominated by fossil
Last two centuries of fossil fuel development:
Un-designed and evolutionary

Percentage of World Supply

Adapted from EIA International Energy Statistics
Size and dominance of fossil fuel industry impedes change.

US government policies - including strategic socio-political policies - are affected by this size and dominance.
The bottom line on current system structure:
- Enormous
- Hard to change
- Uncontrolled evolution

Current trajectory: No change
Issues

- Global-scale planning has never been done before
- The global energy system is complex
- History suggests, without intervention, multiple disconnected drivers will dictate energy development pathways and outcomes
Complex systems are defined as containing diversity, connection, interdependence, and adaptation.

Properties cannot be predicted by studying the underlying components.
Is the global environment/society at a point of transformation beyond the “Information Age”? 

Nonlinear system development (sandpiles) produces unpredictable change
Scenario analyses attempt to visualize possible future states.

Decision-making processes typically focus on optimization within a relatively narrow perspective.

Roadmapping methods support these analyses by strategically charting technological development toward a desired end state.
Innovation may provide the potential to shift the operating environment
A new approach is needed

- Build upon knowable drivers – prepare for unknown future
  - crises / opportunity
- Need viewpoints inclusive of societal goals
- Need to reconsider the problem
Past models and tools

Linear Causality

- Identifies short-term implications
- In stable situations, can forecast longer-term trends.
- Narrow-short-term optimization
- Provide simple, straightforward explanations
  - But: may mask systemic causes / issues
Past models and tools

Circular Causality

- Feedback loops and self-reinforcing cycles.
- Most useful with closed systems with controllable drivers.
- Tools (e.g. systems dynamics models) provide insight into longer term, more widely distributed impacts.
New Tools and Approaches

Complexity:

- Allows a view into
- Emergent system properties
- Competition between systems
- Characteristics of highly interrelated systems
New Tools and Approaches

Complexity:

- Focused on relationships
  - between agents
  - with system structure
- Provides insights into globally interconnected energy system
  - revealing the dynamics of change
  - impacts of policies and constraints

http://www.cmth.bnl.gov/
Reflexivity

- Thinking systems versus natural systems.
  - Incorporates essential human differences
  - Human as part of the environment
    - feedback loops to/from/within the environment
    - Not omniscient ‘observers’ of a natural world
  - Fallibility - inability to ‘see’ the whole system
- Extends the circular effects of other models
  - Considers how decision makers are affected by the system, and how they affect system outcomes
Reflexivity

- Explains innovation as pivot point for nonlinear system shifts
- Use to explore/anticipate impacts of entrenched system agents
- Allows development of more agile responsiveness and resilience
- Extended perspectives allow the gathering/exchange of key information about the system
Reflexivity

- Provides greater understanding about self-organized innovation networks
- May enable progress toward higher order sustainability and energy security goals.
In a changing world, decision makers need tools to gain insights into the dynamics of shifting systems.

In order to understand global energy systems, the qualities of resilience, agility, and adaptability are critical for dealing with unknown and emerging challenges, and for enabling the seizure of opportunities.