Energy Ecologies

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Introduction

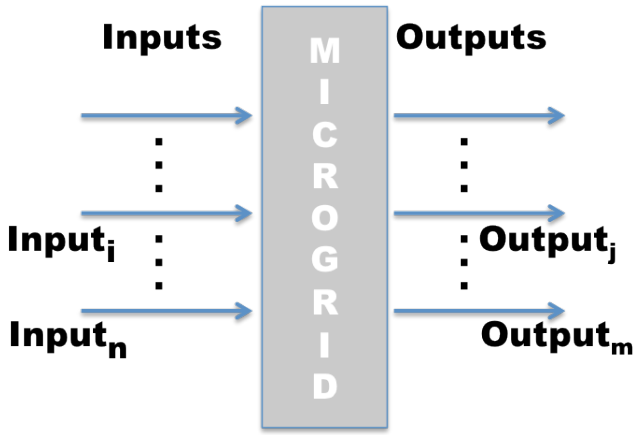
- William Cox
  - Principal, Cox Software Architects LLC
  - Consulting Software Architect
  - Specializing in Smart Grid architecture and information definitions
- Toby Considine
  - Principal, TC9, Inc (www.tcnine.com)
  - Strategic Technology Consulting
  - Enterprise integration of Smart Buildings and Smart Energy

What Are Energy Ecologies?

- Ecology from Greek:
  - οἶκος, "house"; -λογία, "study of"
- Economics from Greek:
  - οἰκονομία (oikonomia, "management of a household, administration")
- Energy Ecologies: The study of the economic interchange, conversion, and management of energies within a facility or microgrid

The View From a Node

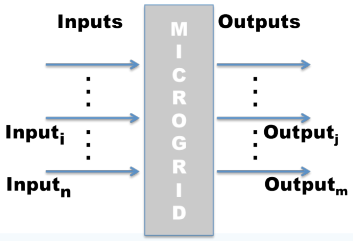
- 0..n Energy Inputs, 0..m Energy Outputs



Grid-Interop
Driving to Grid 2020

At the Node

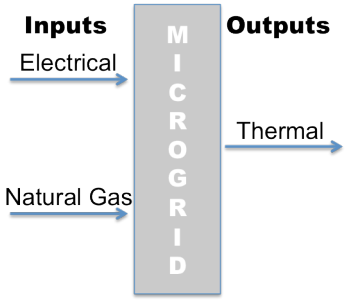
- Each available input
  - Has a price and product definition (including time)
  - May have EMIX source warrants
- Each possible output
  - Has a price and product definition (including time)
  - May have EMIX source warrants



Grid-Interop
Driving to Grid 2020

Example: Dual Fuel Boiler

- A dual-fuel boiler can use multiple sources
  - For example Natural Gas and Electricity
- Cost of input may be mitigated by cost of output
  - E.g. Steffes paper, Grid-Interop 2011

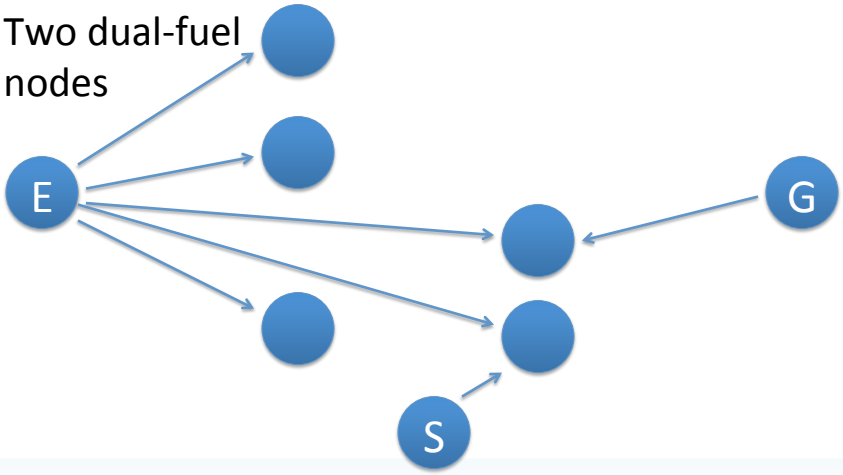


Example: Storage

- Storage can take many forms
  - Time-delayed output, bounded storage
  - Energy embodied in finished product
    - E.g. aluminum embodies large energy costs of production
  - Energy embodied in intermediate product
    - E.g. forged blanks for further machining
- Involves delayed flows
  - Petrie nets or similar techniques may be more intuitive

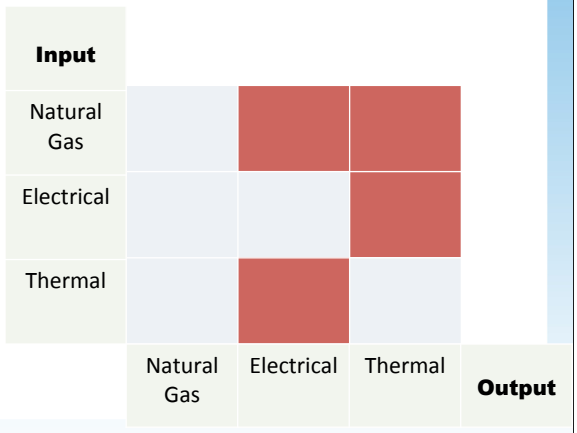
The View "Outside the Paper"

- A graph where the vertices are nodes and the edges are potential transformation links
- Two dual-fuel nodes



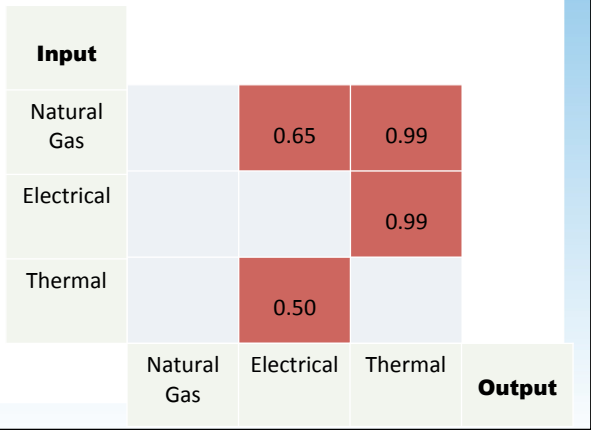
Feasible Transformations

- Without extraordinary measures, only some conversions are feasible
- Ignore like-to-like



Conversion Efficiency

- Sample conversion efficiencies
- Not necessarily for real devices



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Input Cost

- Input costs in cents/MJ (cents per megaJoule)
- Prices for natural gas and electricity are NJ prices November 2012
- Price for thermal is a guess
  - Used the value of the natural gas assuming high efficiency of transformation

Input Cost C/MJ	
Natural Gas	0.5
Electrical	3.2
Thermal	0.5

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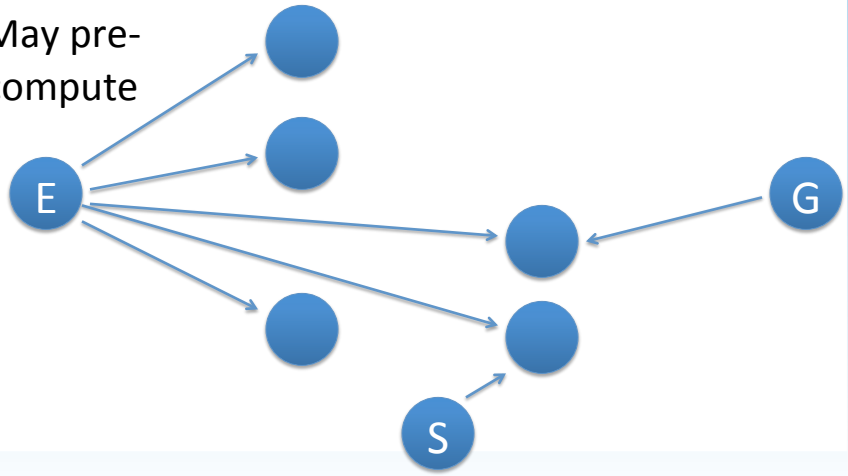
Output Cost

- Multiplying (Input Cost / Efficiency)
- Costs are cents/MJ

Input				
Natural Gas		0.79	0.52	
Electrical			3.25	
Thermal		1.02		
	Natural Gas	Electrical	Thermal	Output

Discovering Sources

- Find feasible transform source among inputs
- If none, use graph search algorithms
- May pre-compute



Complexity and Other Issues

- The graph of nodes, input and output links is sparse
- Input costs are less simple than shown
- Input costs, hence output costs
  - Are time-varying
  - May have thresholds where costs change
- Imputing of capital and (internal) distribution costs is difficult
- Flow rates will vary
- Constraints on flows and storage require models

Benefits

- Robust and resilient systems can discover alternate sources for specific inputs
- Common framework for cost
  - Using matrix algebra
  - Many input costs are consistent across a facility
- Simple conceptual model for use of diverse energy sources
- Simple conceptual model for outputs

Questions

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