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Dr. Ron Carson, PhD, ESEP,
Seattle Pacific University, University of Washington

Not-In-My-Backyard is not Sustainable

Outline

- Identifying NIMBY
- The challenge of distributed architectures
- Exergy is a measure of Sustainability
- Transportation is not Lean
- NIMBY affects system coupling
- Costs and benefits should be aligned

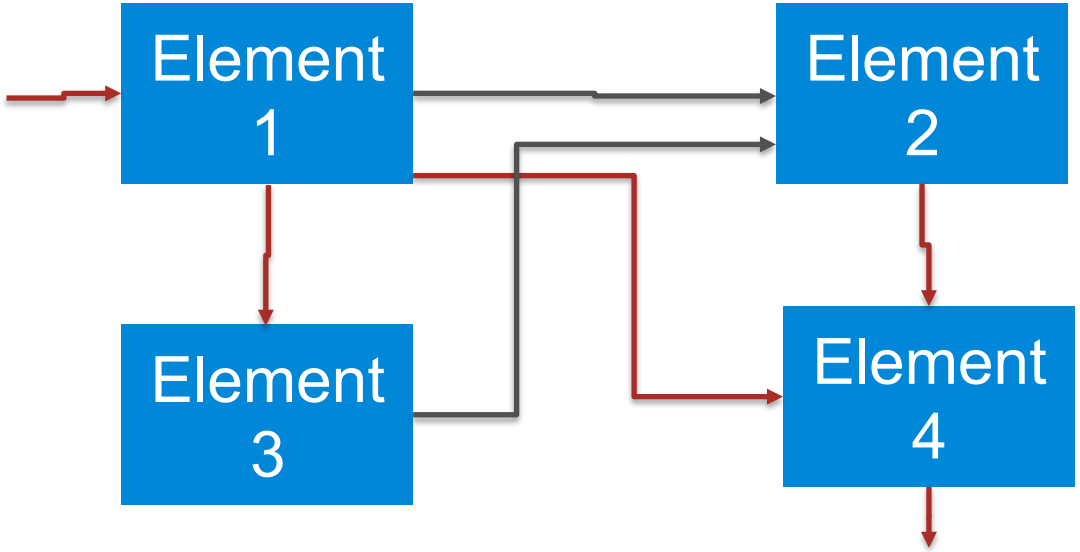
Identifying NIMBY – Not in MY Backyard

- Mobile phones and towers
  - All phone users benefit
  - Those near mobile phone tower are negatively affected
- "I want a mobile phone (as long as the tower is not in MY backyard)."
- NIMBY applies when benefiters reject *location* of supplying system – public or private infrastructure

Image Author Joe Ravi, CC-BY-SA 3.0

The Challenge of Distributed Architectures

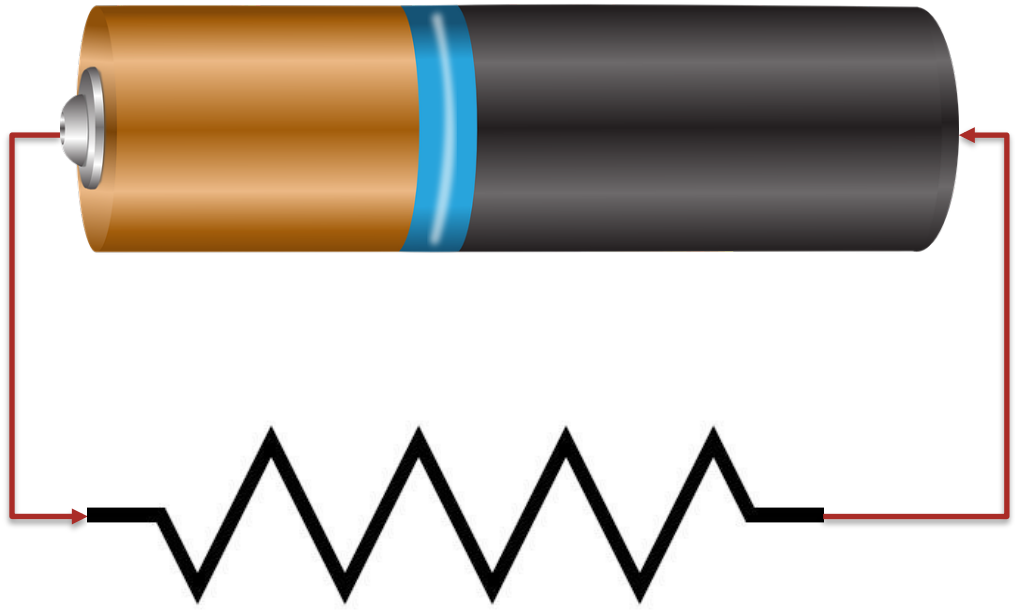
- NIMBY physical separation of system Elements and Functions reflects a *distributed* architecture
- Distributed architectures require *transporting* something to/from another Function and Element via an interface



- "Loose coupling" and "Functional cohesion" reduce interfaces and transportation
  - ➢ Inherently "leaner" architecture

Exergy is a Measure of Sustainability

- "Sustainable" means it is still available to future generations
- Exergy is "available work":
  - Electricity, kinetic energy, potential energy, work from heat
- Exergy is *destroyed* in irreversible processes (the complement of entropy)
  - Conversion to heat *destroys* exergy
- Exergy destruction directly measures ***unsustainability*** because energy is *no longer available* for work



https://qph.ec.quoracdn.net/main-qimg-fb1465cf80421d5cf6ab93d109fb10a0-c

Why do we Transport?

- Resources are not local
- Zoning – a form of NIMBY
- Value of goods/services increases based on location
- System optimization (resources from different locations require transportation to *somewhere)*

Exergy Destruction in Transportation

- Examples:
  - Electricity production and use
  - Water: Urban centers in deserts (Los Angeles, Riyadh)
  - Food and other materials
  - Information and decision-making

Transportation is Not Lean – Exergy Destruction in Transportation

- Lean principle: Any *unnecessary* movement of the thing being processed is Waste
  - *Necessary* movement may be acceptable
  - What is “necessary movement”?
    - Value gained outweighs cost of transportation
  - Sustainability and exergy only consider “cost”, not “value”

Transportation Destroys Exergy

Technology	Exergy Destruction (SI)
Rail (freight)	0.12 MJ/tonne-km
Truck	0.31 MJ/tonne-km
Barge	0.093 MJ/tonne-km
Rail (passenger)	1.6 MJ/passenger-km
Airplane	1.5 MJ/passenger-km
Bus	2.7 MJ/passenger-km
Car	1.9 MJ/passenger-km

- Pipeline: 0.181 MJ/tonne-km
- Networks: ~36 MJ/Gbyte
- California Water Project: 0.00469 MJ/tonne-km/yr (4400 GWh/yr→500 MW average)

“Eating Local” May Destroy More Exergy

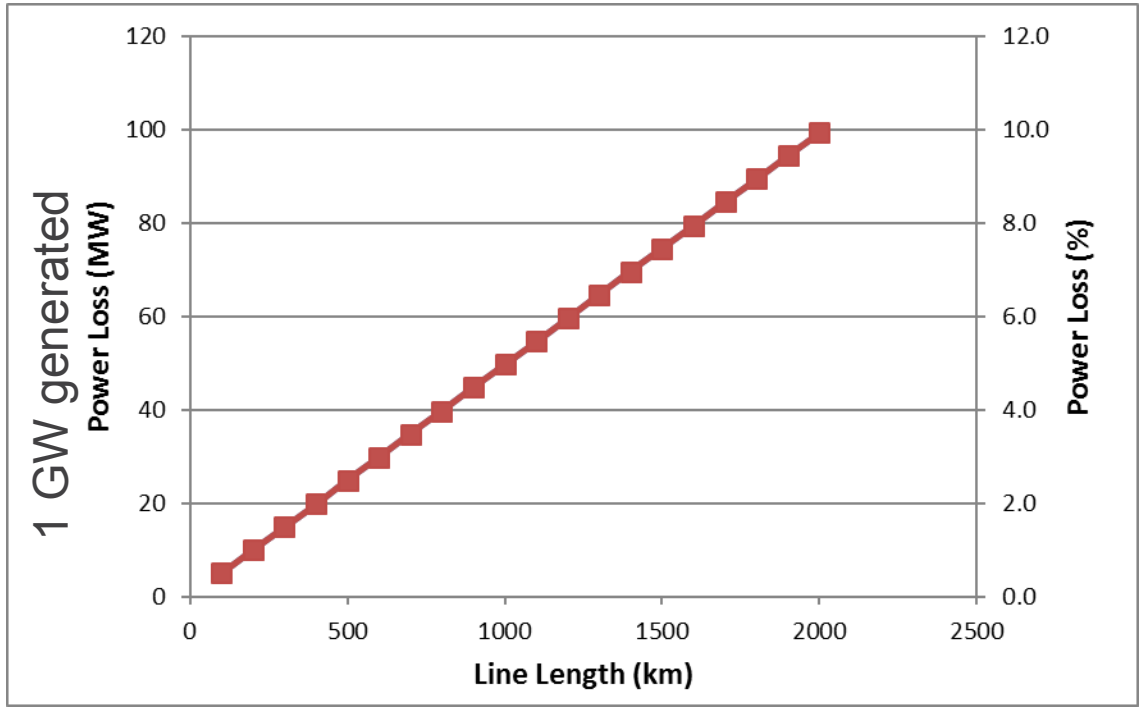
- Agriculture requires plentiful water
- Exergy is destroyed if the *water* must be transported
- Better architecture is to grow and process food local to the *water resource* to minimize transportation

- “Eat local” only makes sense if water and other resources are local

Crop / Food	Water Use (Oldham 2016)	Water Use (kg water/kg crop)
Corn	4000 gallons/bushel	572* (Grains 2016)
Wheat	11,000 gallons/bushel	1470
Alfalfa	135,000 gallons/ton	540
Bread	1000 gallons/2-lb loaf	4000
Egg	120 gallons/egg	7228**
* 0.0254 tonne/bushel corn; 0.0272155 tonne/bushel wheat (Grains 2016). ** Using “large” eggs at 2.125 oz./egg (Kitchn 2013)		

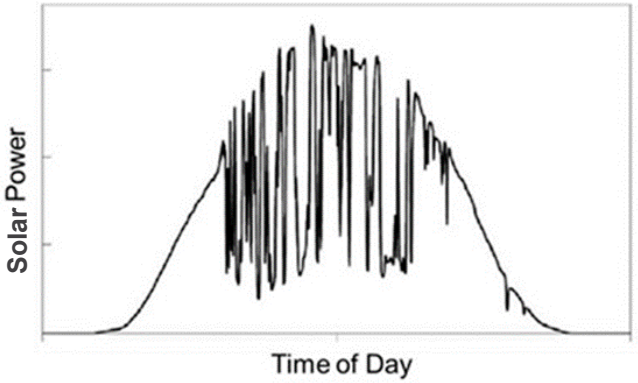
Electricity Transmission Destroys Exergy

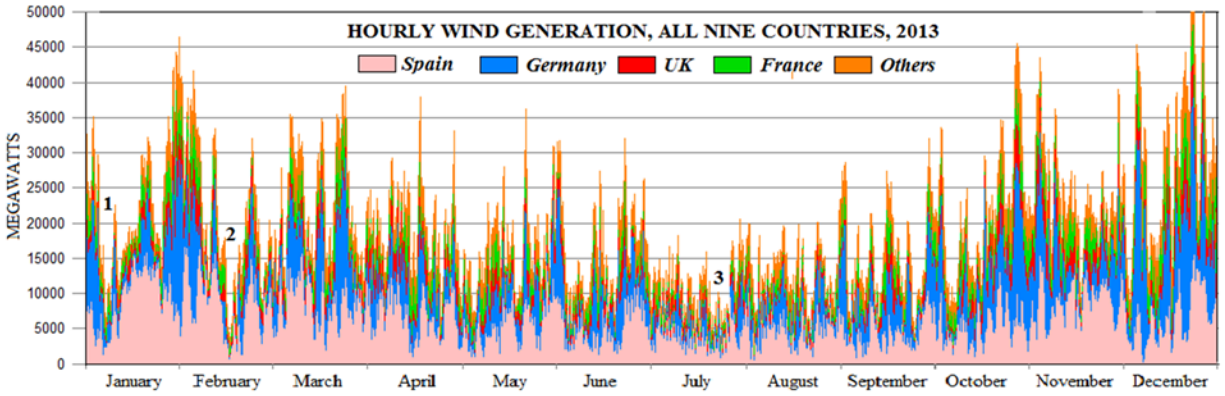
- "NIMBY" power plant moves power generation away from power consumption
- As much as 10% of generated exergy is destroyed at 2000 km transmission

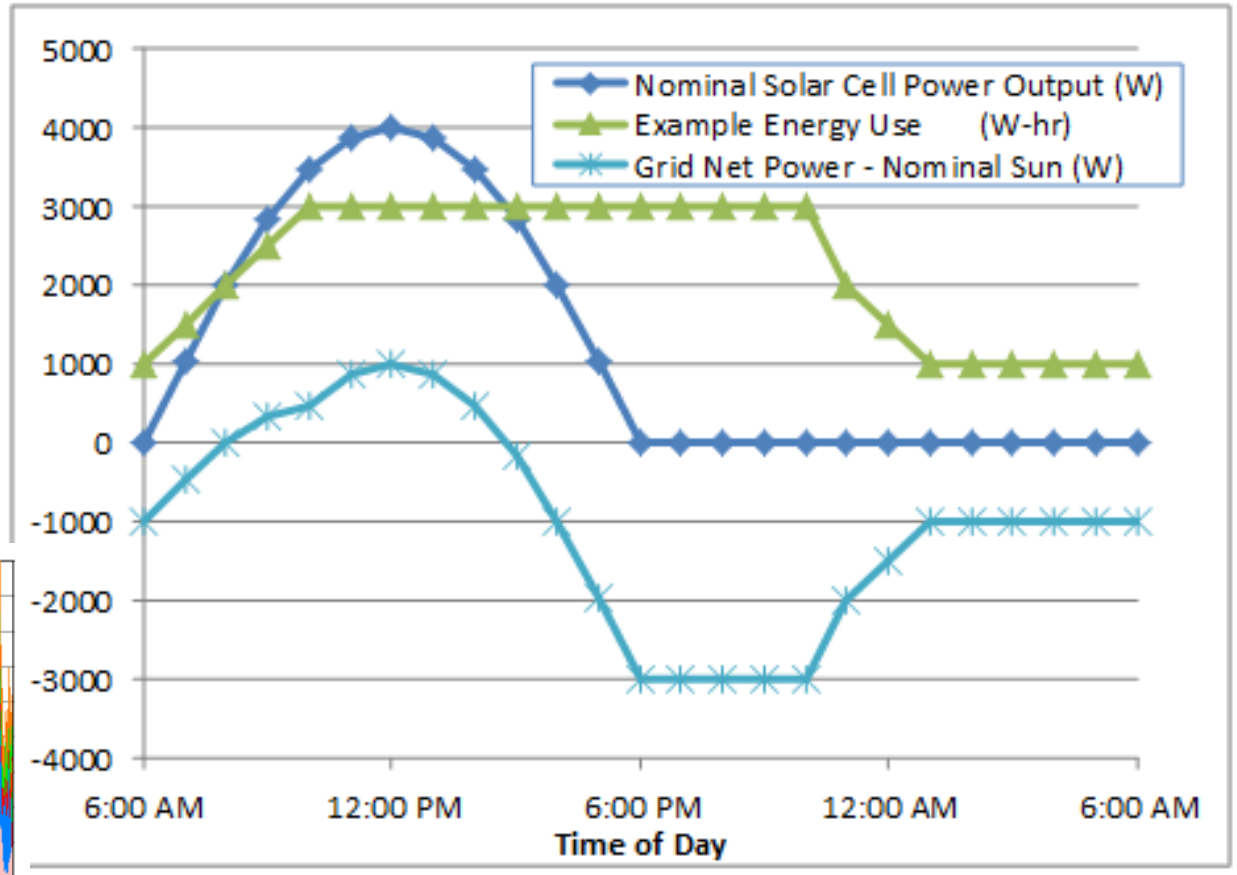


Non-local Coupling – Solar & Wind Power

- Are home-based solar and wind systems a *sustainable* resource?
  - Materials depletion
  - Power source variability

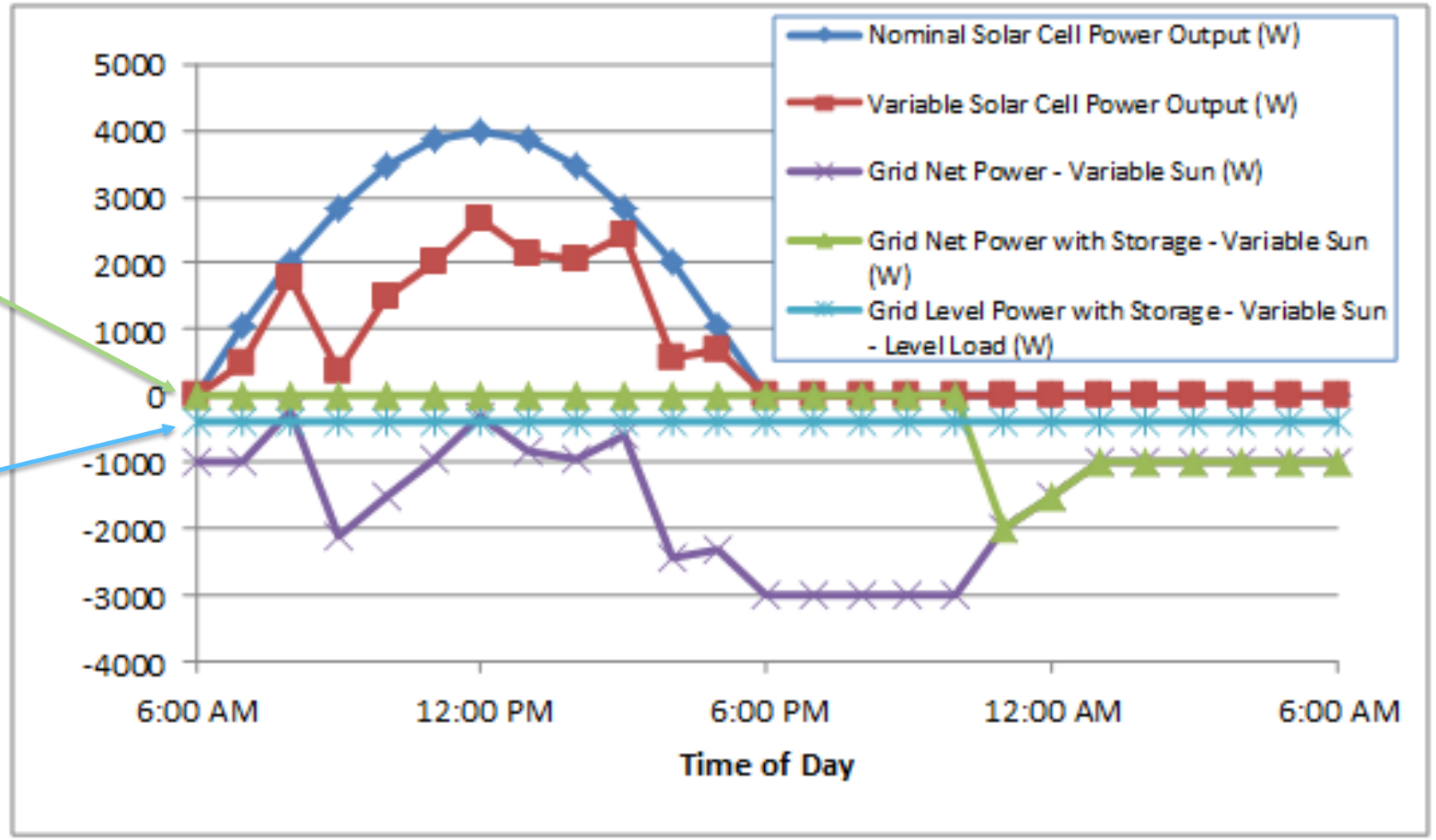






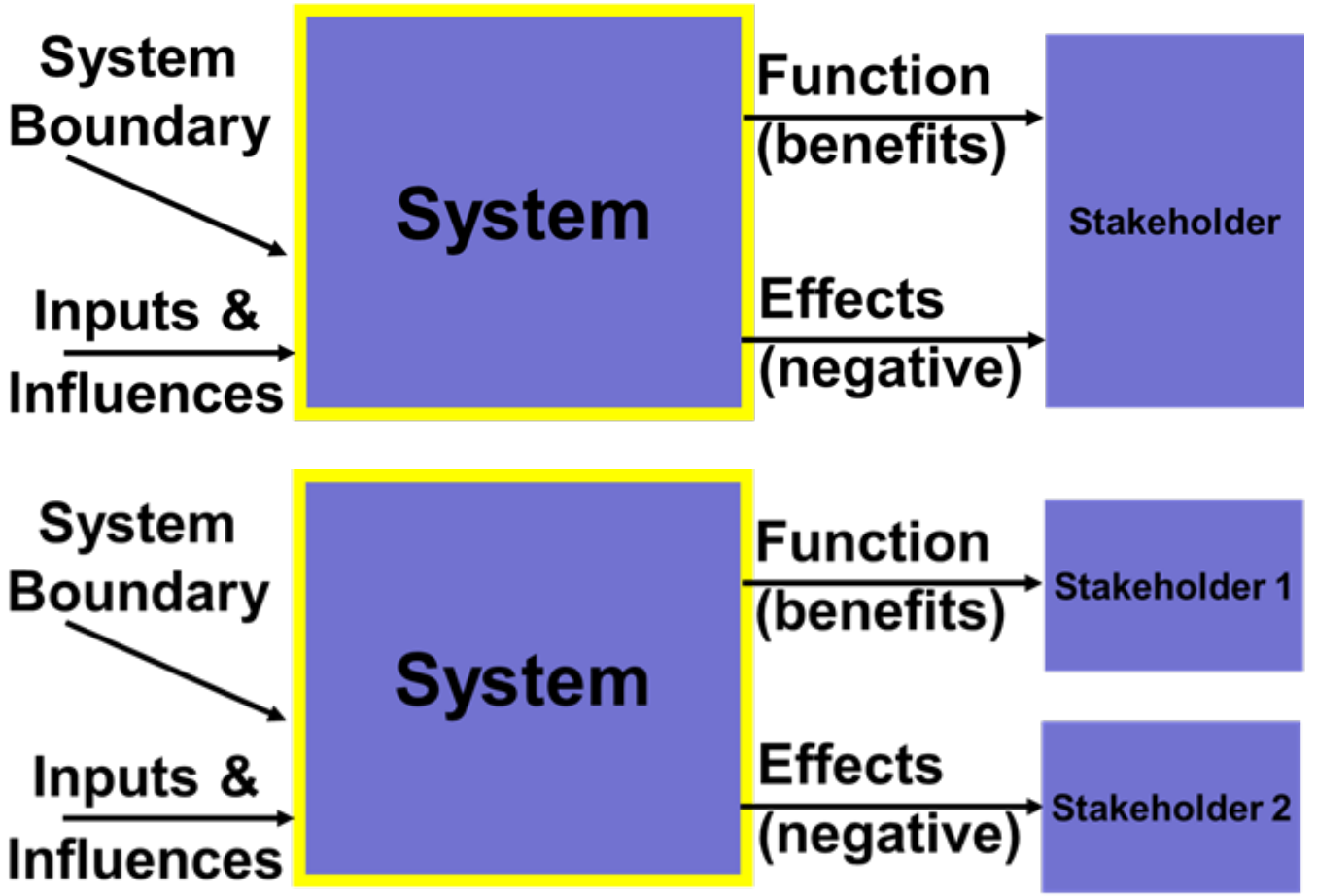
System Effects of Variable Distributed Source

- Variable distributed source yields high fluctuation in grid loads
- Often compensated by fossil fuels with low utilization (higher costs)
- More sensible to require local energy storage to smooth grid loads and eliminate need for unused utility capacity
- “Net-metering” vitiates system benefit while enriching individual producers



Externalities: Who Pays? Who Benefits?

- Equitable or “just” system architecture would assign costs to benefiter
- In practice, this is sometimes not realized (“externalities”)
- One consequence is lack of “acceptability” to those negatively impacted
- NIMBY is one example of this effect – even those receiving benefit do not want the costs!

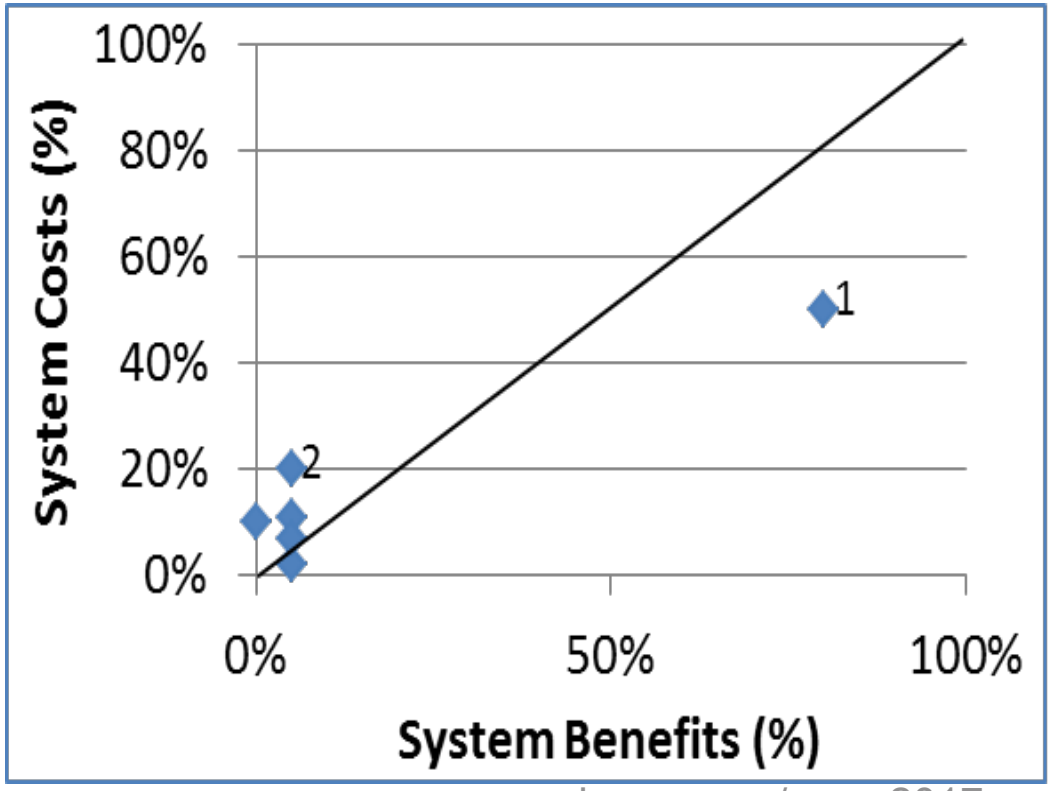


Example: Externalities in Transportation

- ~1997 US vehicle and infrastructure costs
  - US$674 billion/year
  - Infrastructure costs: US$78.3 billion/year (paid by taxes and fees)
  - US$118 to US$372 billion/year is not fully reflected in user fees or in private costs – the externality not borne directly by the benefiters (18% to 55%)

Measuring the Misalignment of Costs and Benefits

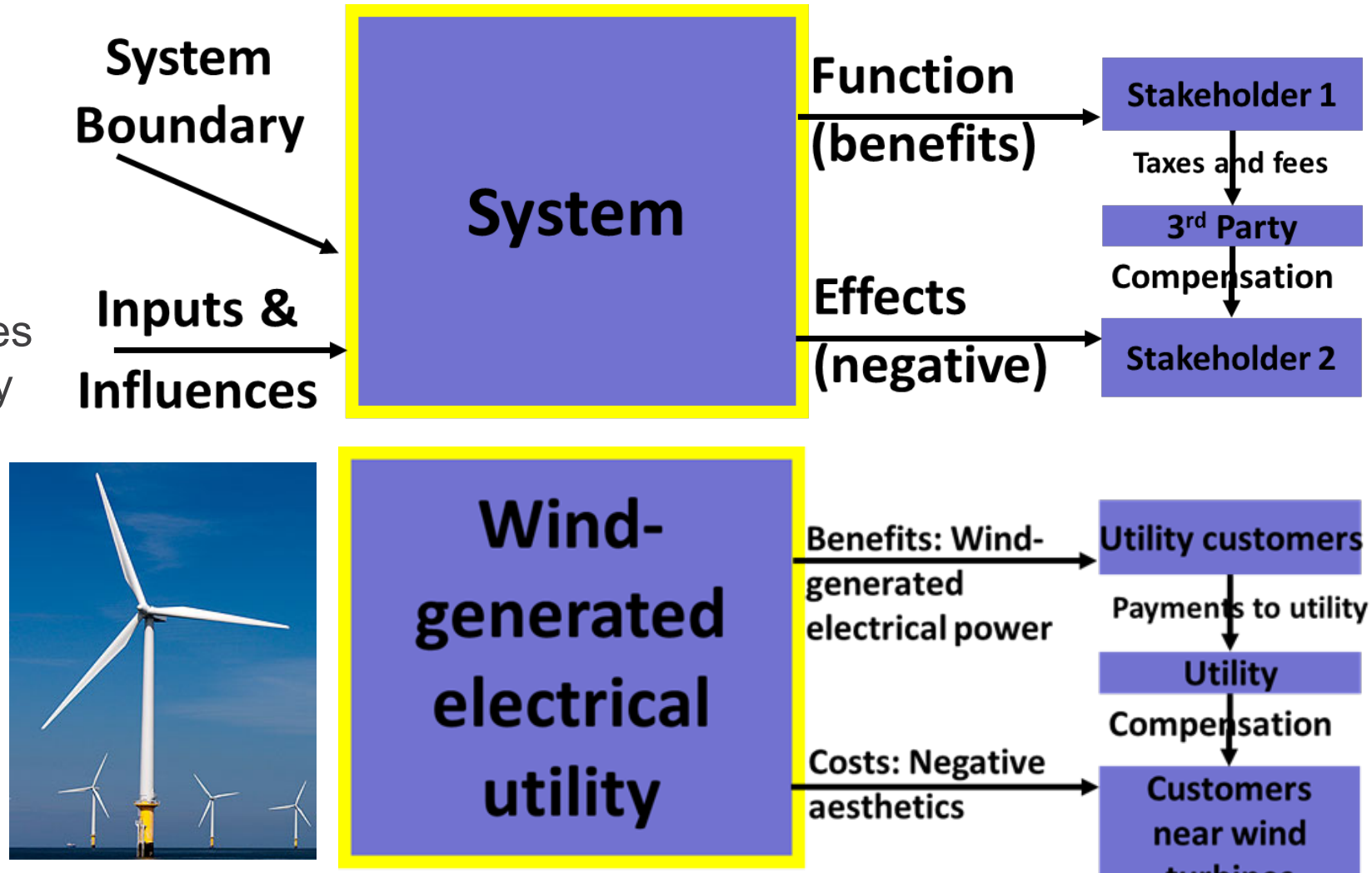
- How can we transfer costs to benefiter (align costs to benefits)?
  - Measure the costs and benefits
  - Regulate or incentivize alignment



Stakeholder	Net Benefit
1	+30%
2	-15%
3	-10%
4	+3%
5	-6%

Improving Cost/Benefit Alignment

- Compensate costs with additional benefits
  - Regulation (government, taxes, fees)
  - Market-based, e.g., locales can bid for the opportunity to bear the costs and receive the negotiated compensation



https://www.capewind.org/what/overview

Summary

- NIMBY is a subset of the problem of misaligning costs and benefits among system stakeholders
- Sustainable, distributed architectures must account for exergy destroyed in transportation of people, resources, information and other externalities
  - Less exergy is destroyed when transportation is reduced
  - This is a more *sustainable* architecture
- If costs are properly accounted and allocated, more optimal and sustainable architectures should be realized

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