Decentralized Energy Management and Virtual Power Plants

Experience you can trust.

KEMA has been serving clients for more than 80 years

Serving electric utilities' diverse needs from generation to retail

- Three primary business lines:
  - Consulting
  - Testing
  - Certification
- 1,700 professionals in more than 20 countries
- Annual revenue of $300+ million

Independent experts to the global energy and utility industry

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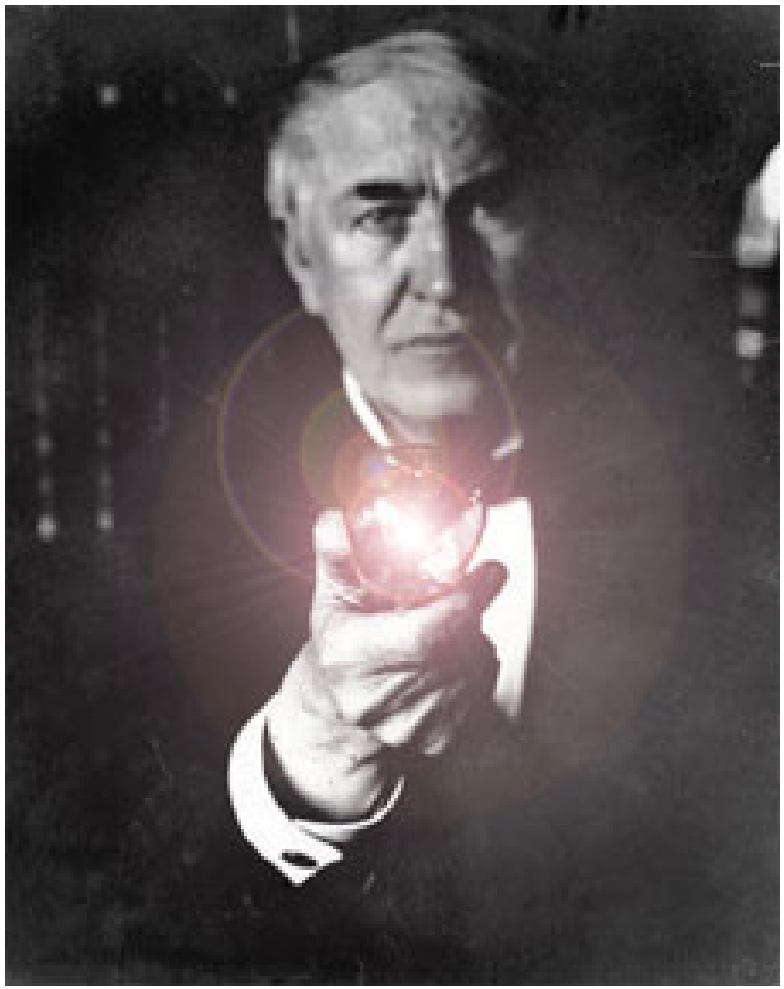
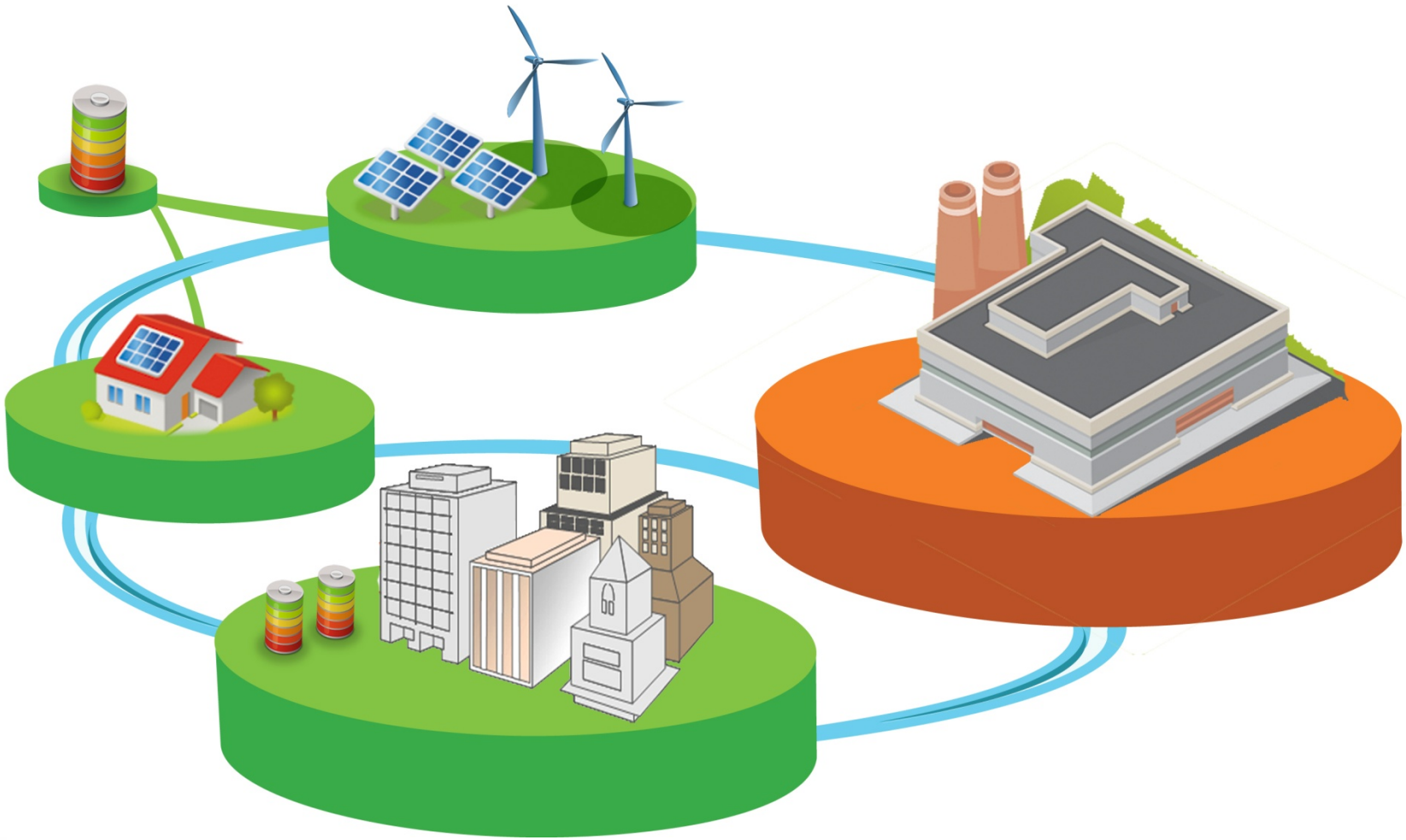
Can we improve a system designed 100 years ago?

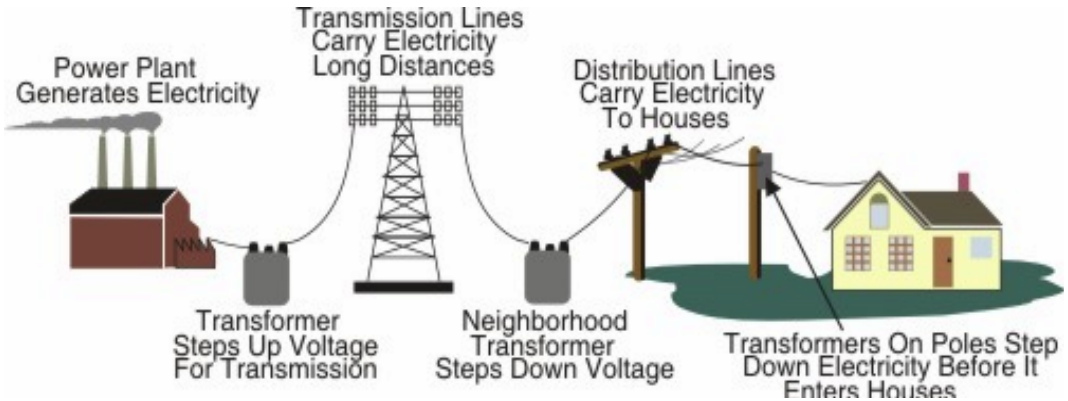


Sustainability requires a new architecture which connects –generation, storage, network assets to load “communities”

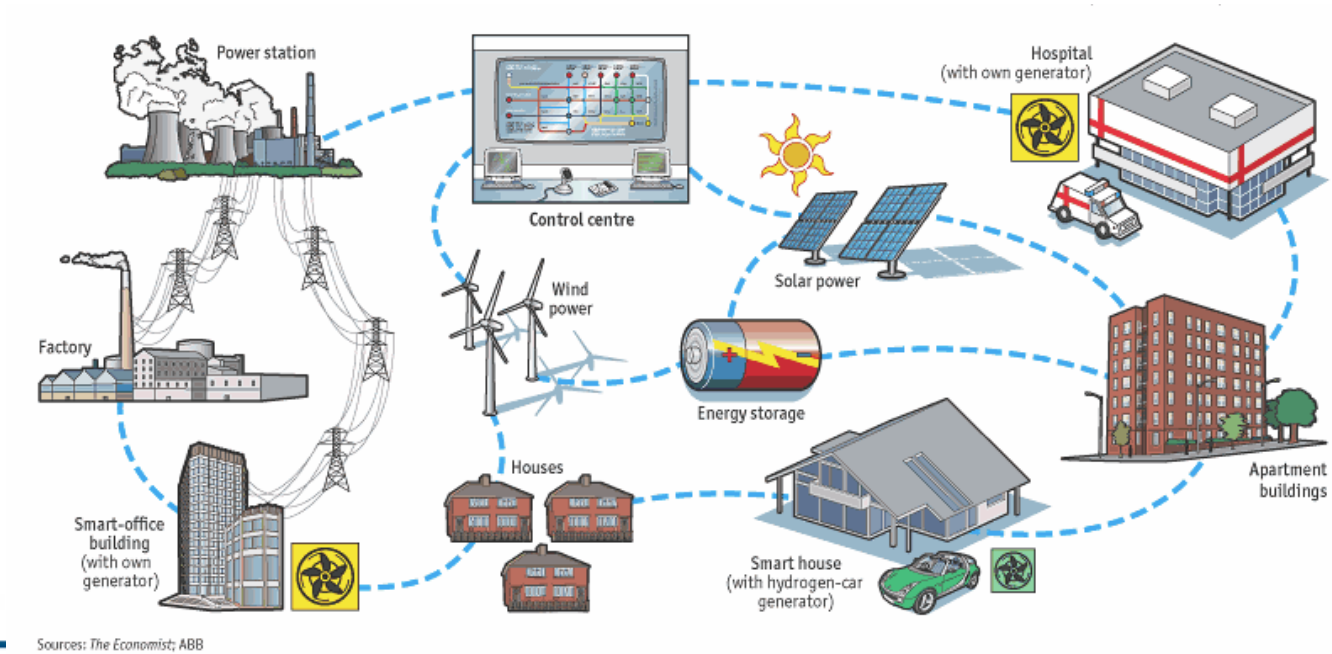


The Evolution of the Grid

Edison's Grid:
<u>One-way</u> power flow, simple interactions



***The New Grid*:**
<u>Two-way</u> power flow, multi-stakeholder interactions



Adapted from EPRI
Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Matching Generation with Loads

- Macro
  - If you span enough geography will ‘everything balance out?
  - European Road Map 2050
- Regional
  - California 33% renewable penetration
  - How will things work within a narrower geography?

European Climate Foundation

EU Roadmap 2050

Decarbonization for the EU-27

Electrical Grid with 80% renewable energy

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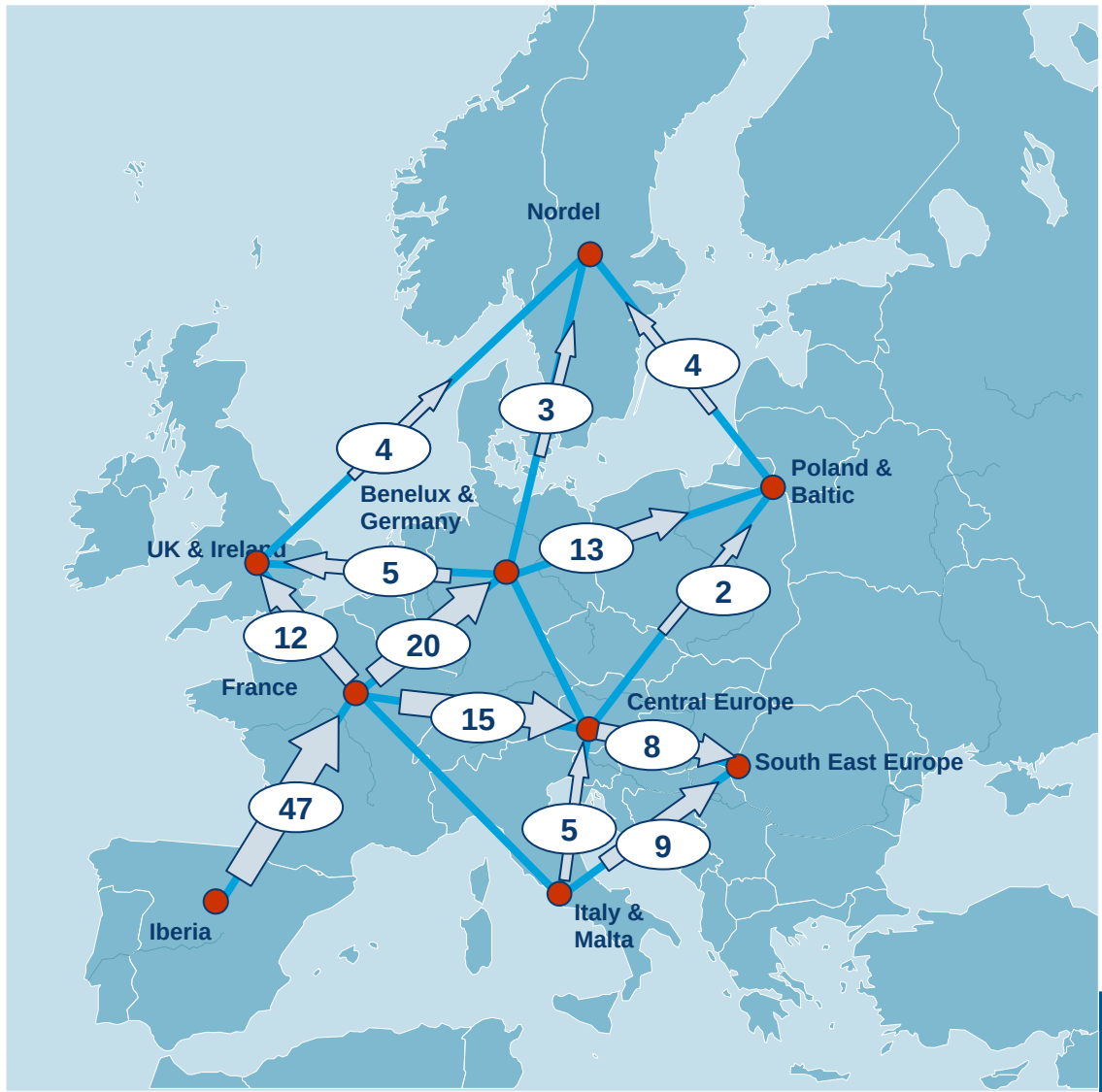
Power flows from South to North on a summer day

Monday July 17, 2050 15.00 CET

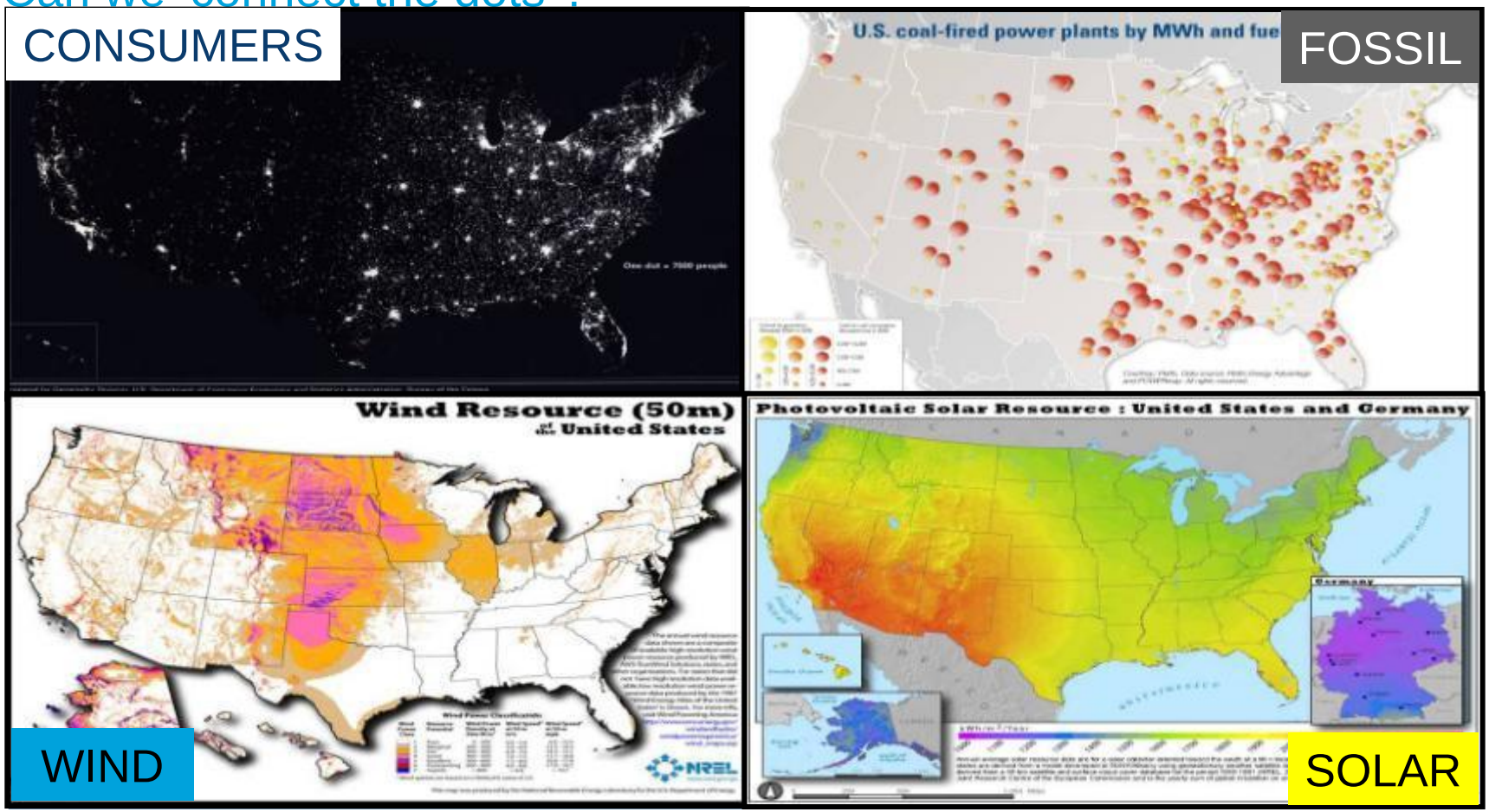


SOURCE: Imperial College; KEMA; team analysis

Optimizing Energy Conversion Geography

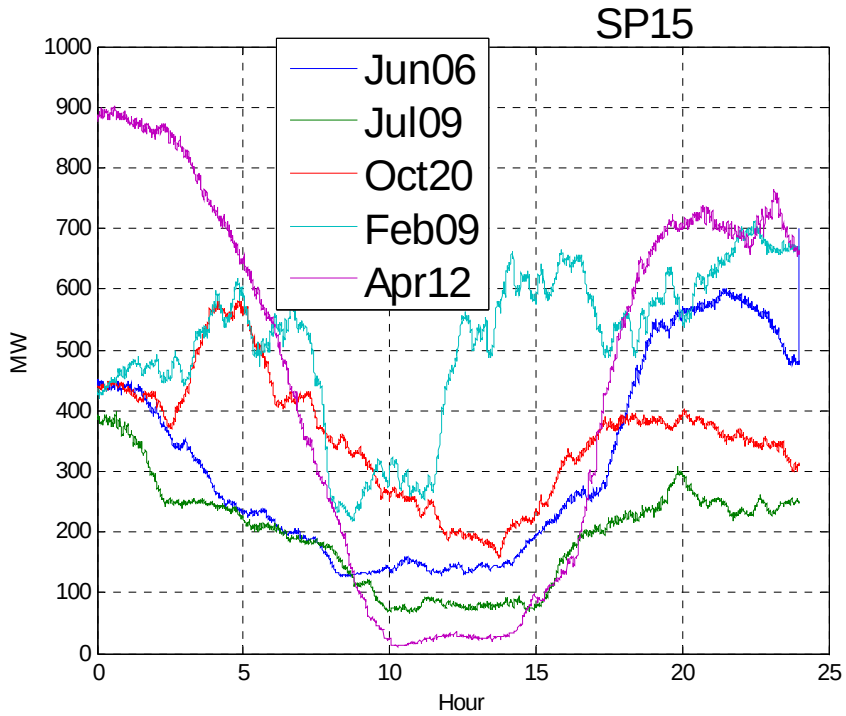
Where is the “fuel” and where is electric power needed?

Can we ‘connect the dots”?



Wind power

- CAISO – Moving to 33% renewables

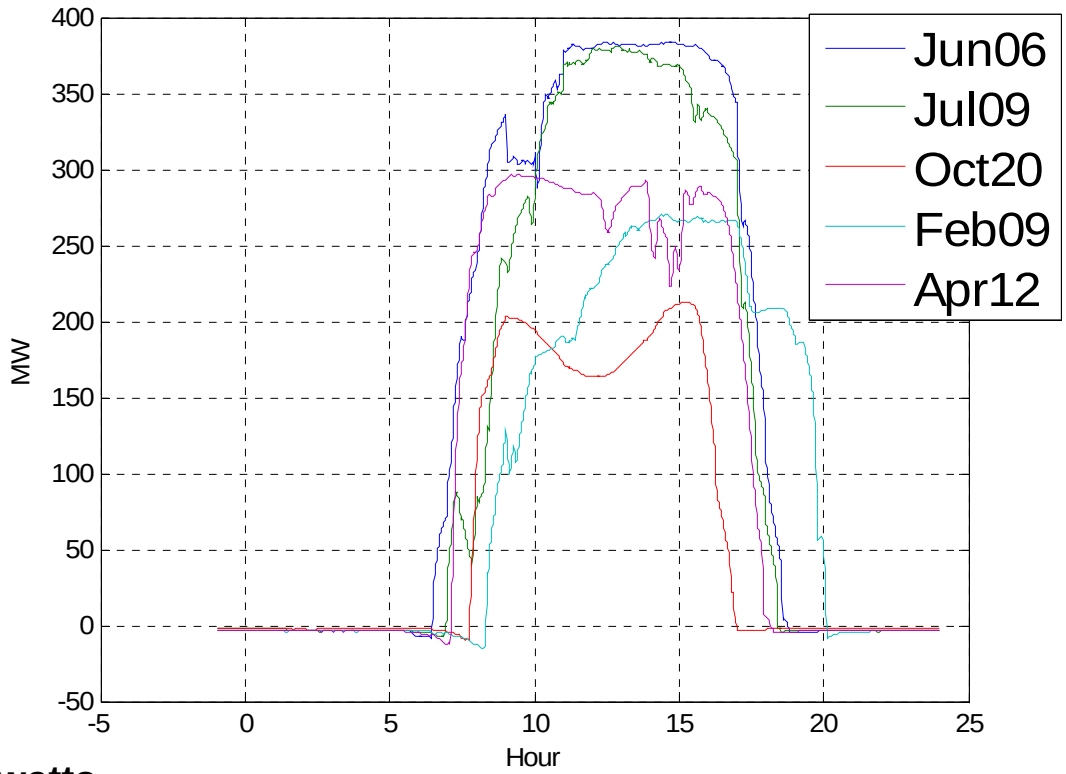


Plant Capacity in Megawatts

Year	2009	2012	2020 low	2020 high
Wind	3000	5917	10972	13000

Concentrated Solar Thermal

- geographic diversity will provide minimal "smoothing"



Plant Capacity in Megawatts

Year	2009	2012	2020 low	2020 high
CST	400	996	7297	10000

Firming of Variable Renewables

- Fossil Firming – tactics & strategies
- **Modify to increase ramp rates**
- **Hidden costs of fossil units "chasing" wind or solar**
  - ***Increased cold starts***
  - ***Increased ramp events***
  - ***Increased run time at reduced loads***
  - ***Decreased window to complete scheduled maintenance***
  - **Result: Decreased longevity and increased maintenance costs**
- **Are other approaches more cost effective?**

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Demand Response Evolution

- **Current Aggregator model**
  - ***Pros and cons***
- **Emerging models (dispatchable)**
  - ***Real time aggregation of distributed loads***
    - ***Commercial customers***
      - ***Building and factory energy mgt. systems now moving to offer solutions***
    - ***Residential***
      - ***UISOL/Tendril example***
  - ***Auto Demand Response (ADR)***
  - ***Smart Grid will expand the options***

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Hybrid Approaches

Will combining different generation types provide benefits?

- **Smooth generation output**
- ***Higher capacity factor***

High levels of interest

- **Cofiring biomass**
  - ***Lowest cost renewable***
- **Solar thermal**

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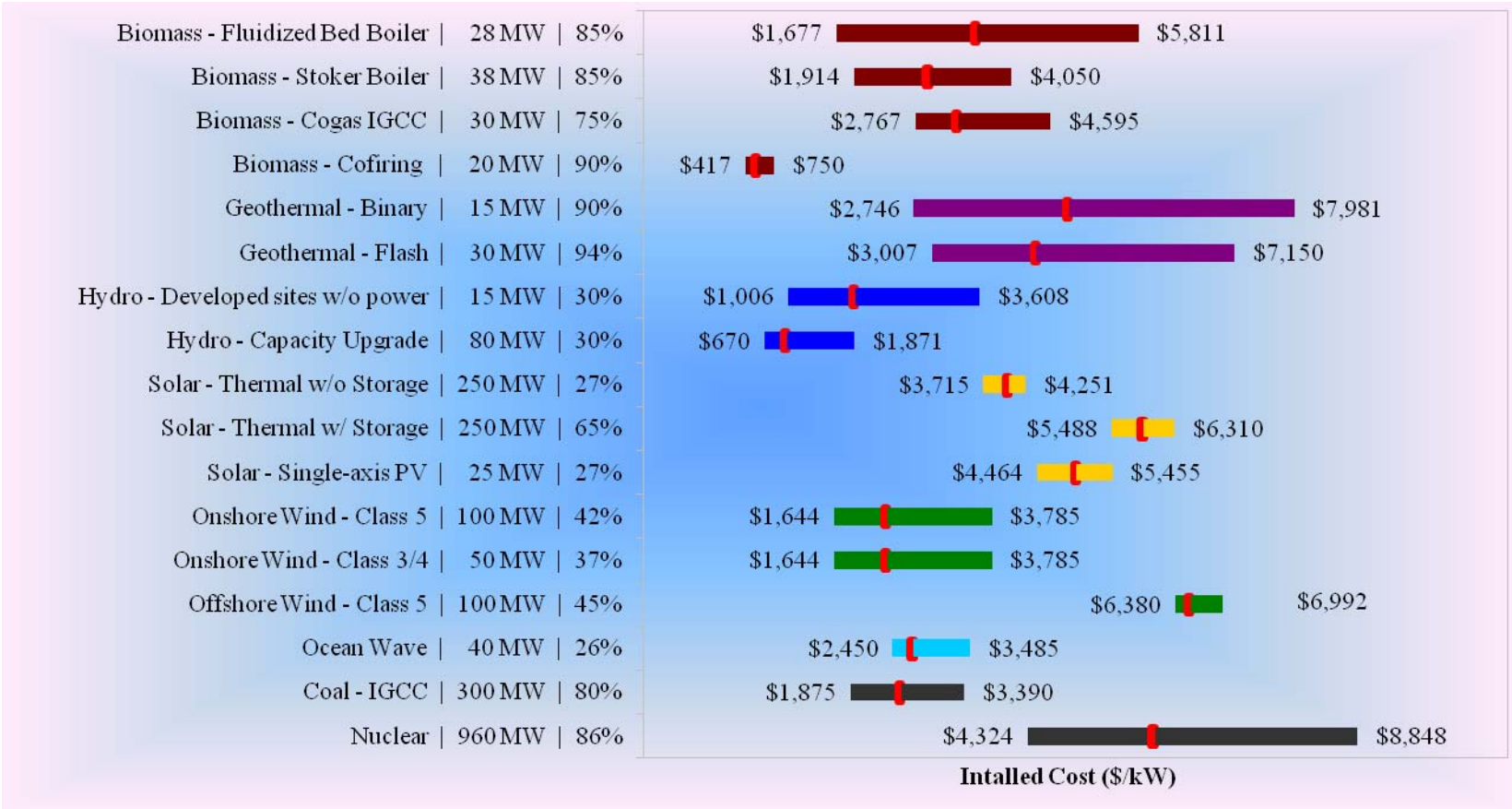
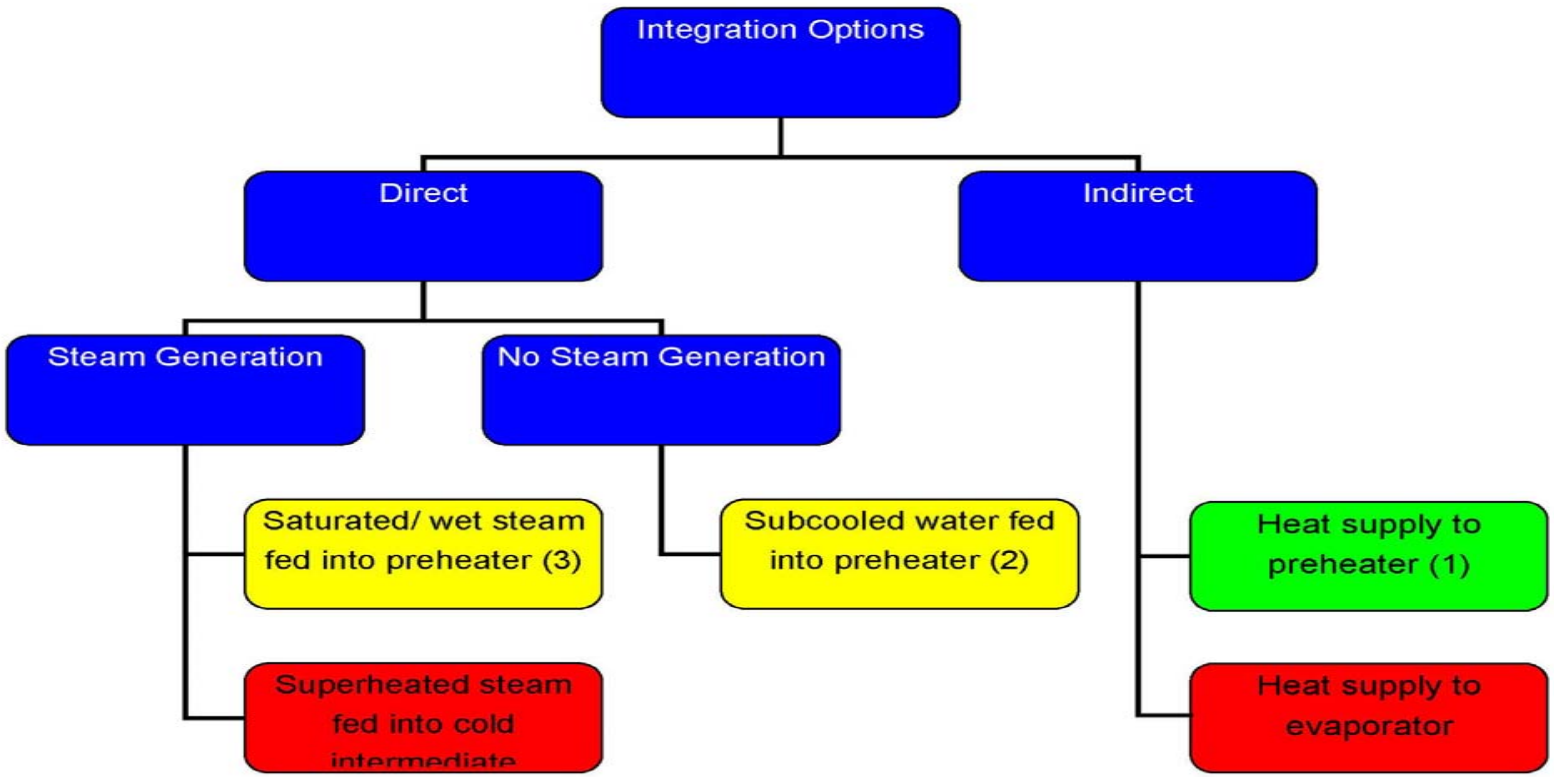
Cost of Utility Scale Generation



Hybrid Solar Thermal Retrofits can be cost effective alternatives



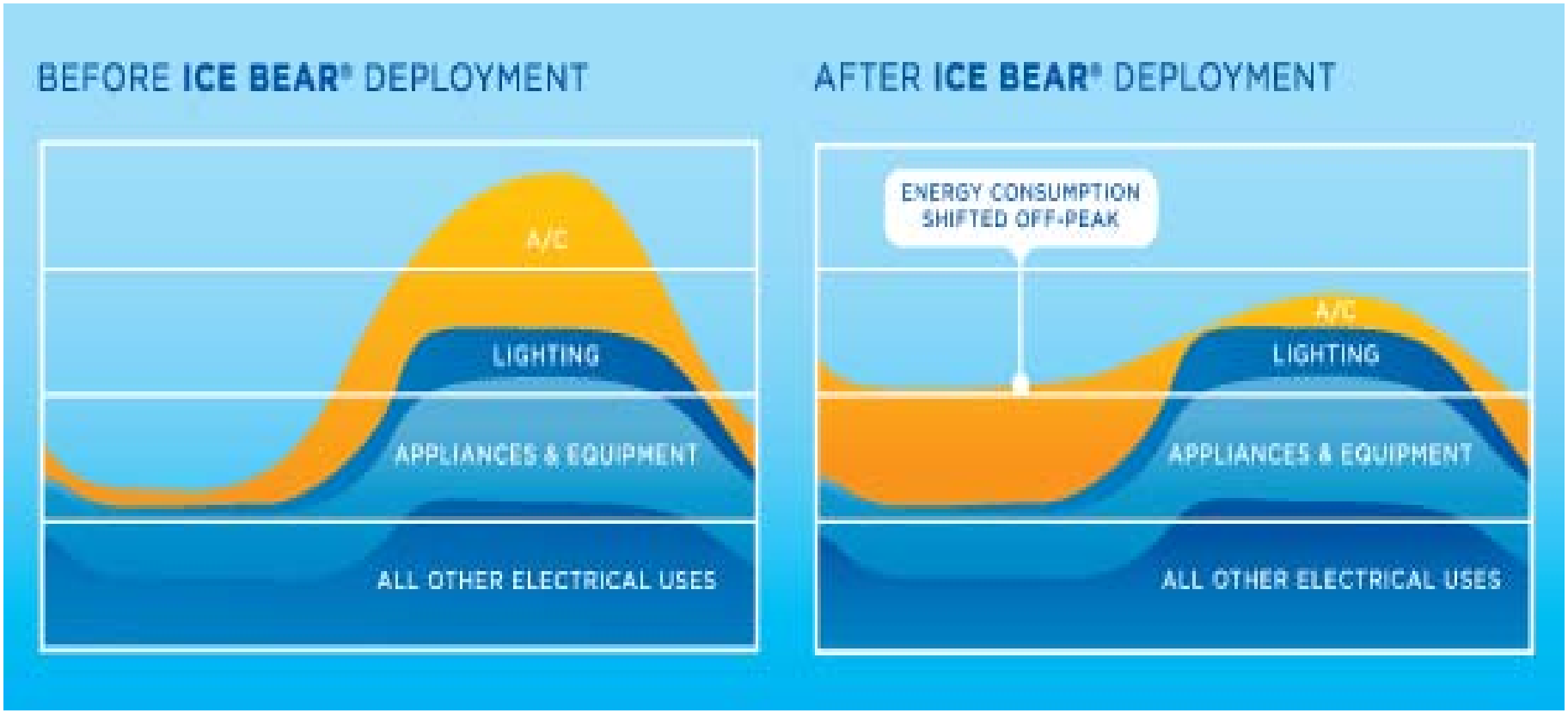
STORAGE

- Is this viable?
- Is it realistic?
- Is it cost effective?

Characteristics of Wind

- Not ‘dispatchable’
- Variable and uncertain output
- Can ramp up very quickly
- Wind output is not usually coincident with peak load
  - Wind is an energy resource, not a capacity resource
  - In some areas peak wind and peak load are 12 hours ‘out of phase’.

How can ice help us utilize wind blowing at night?



Source: Ice Energy

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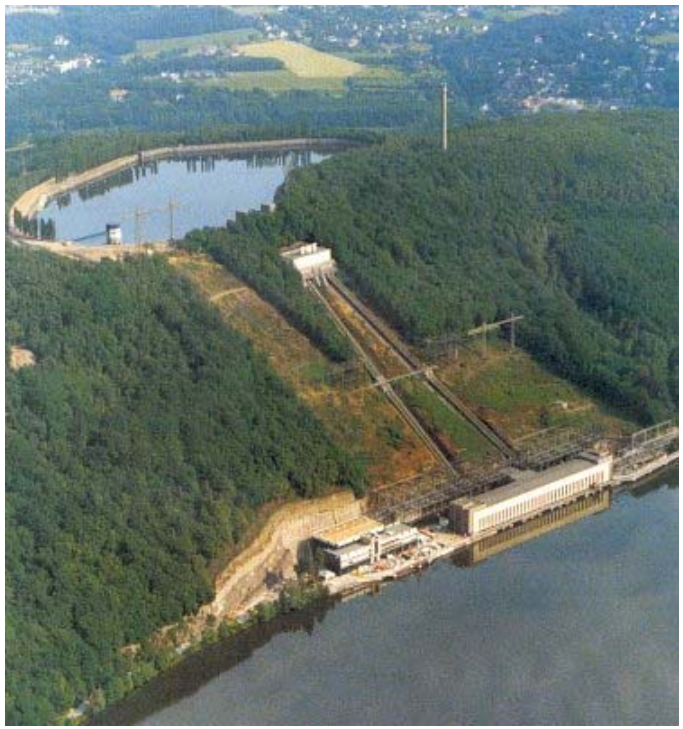
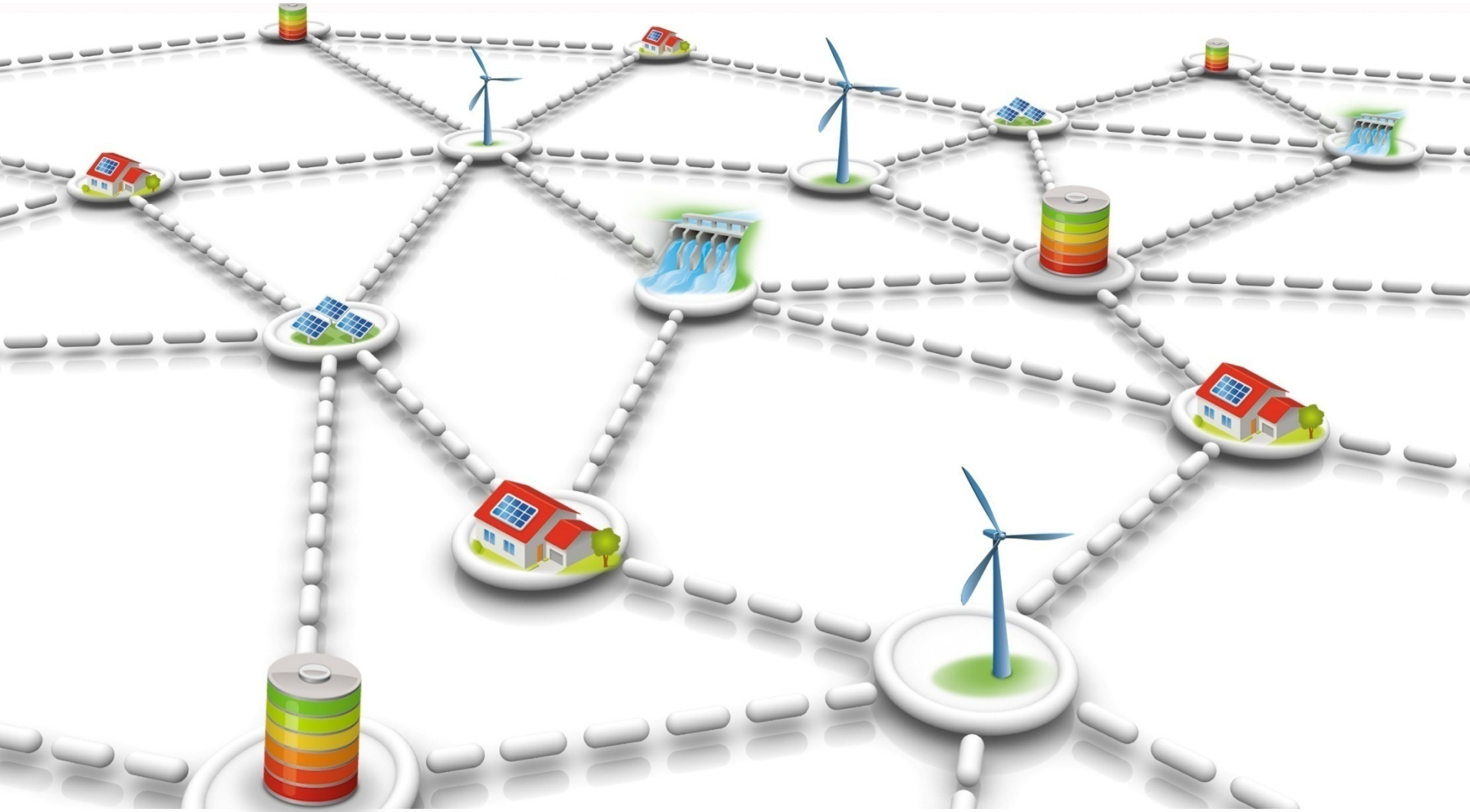
Early Storage for the Grid



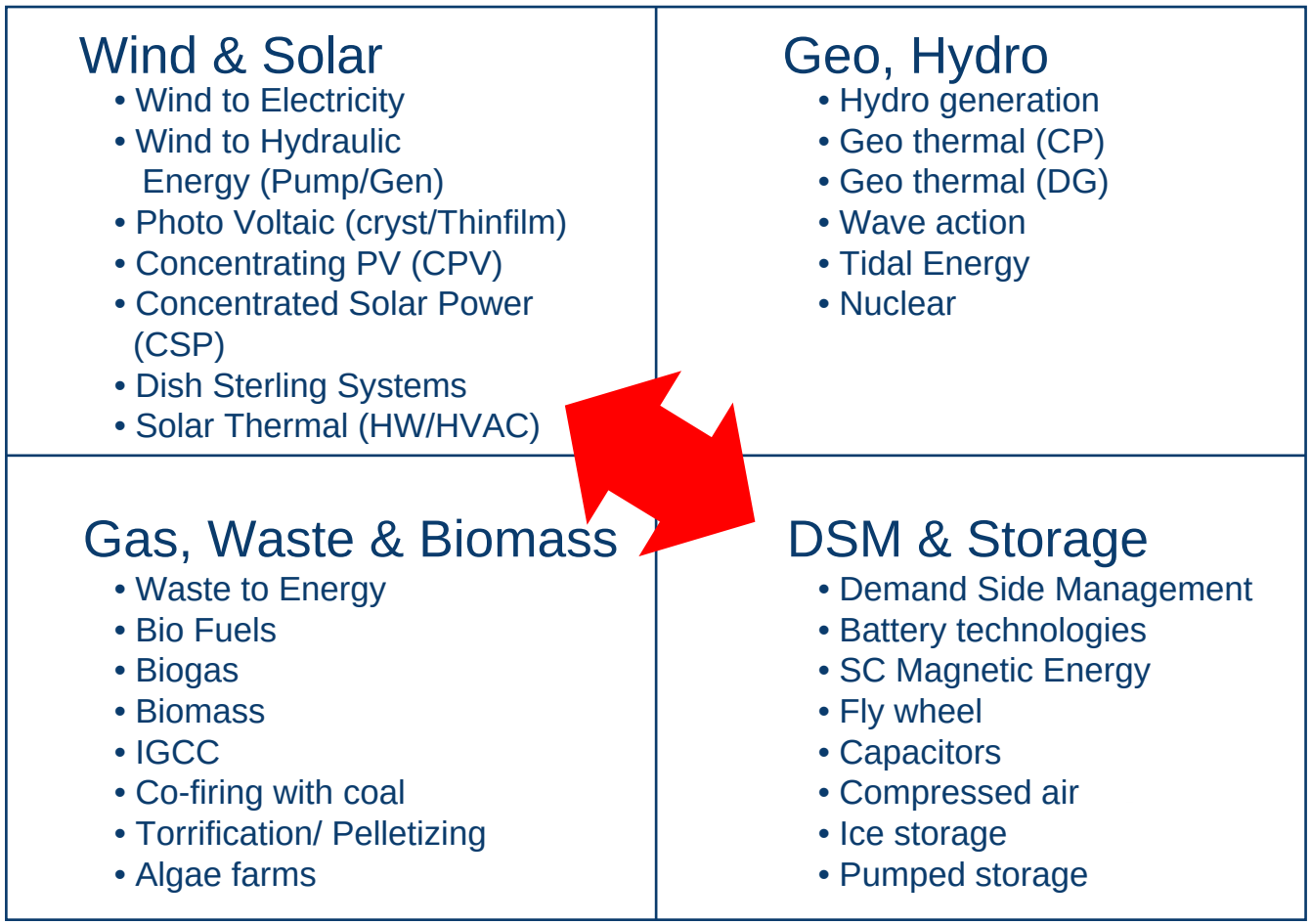
Conventional
Pumped Hydro

Compressed
Air Electrical
Storage

Storage coupled renewables are dispatchable with smart grid.



Coupling renewables, with energy storage improves capacity and stability.



Community Energy Storage (CES)

CES is a small energy storage unit connected to transformers serving a few houses or small commercial loads

- Uses new or used PHEV batteries
- Offers back up power to customers
- Buffers customer renewable generation
- Makes PHEV charging time less of a critical issue

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PHEV Development Examples

Production

(Volumes generally not disclosed)

Tesla Motors
In production
244 mile range EV

Fisher Karma
EREV
2010

Saturn VUE
2-Mode Blended
Intro: 2011 CY

Chevrolet Volt
Extended Range EV
20 to 40-mile EV range
16kWh Li-Ion
Intro: 2010 CY

BYD Auto (China)
2011 USA
2 vehicles

Demo

Ford/Eaton Trouble Truck
10 truck fleet w/ utilities

Ford Escape PHEV
2008 CY, 21 car fleet
with SCE/EPRI/Utilities

Toyota Prius PHEV
500-car fleet
2009 CY

Mitsubishi iMIEV
2010 CY, 100 mile range,
PG&E, SCE demo

Subaru R1e
50 Mile AER
10-car fleet 2008 CY

VW Golf Twin Drive
30 mile EV range
20-car fleet, 2009

Daimler Smart ForTwo
2010 CY

Concept

Dodge ZEO
150-200 mile range

Nissan
2010 CY

2008 **2009** **2010** **2011** **2012**

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Electric Vehicles on your grid

- **Disruptive impact**
  - ***Extend and increase grids peak demand***
  - ***Potential overload of suburban transformers***
  - ***Potential overload of transformers & circuits in commercial zones for employee/fleet charging***
  - ***Shorten transformer life – limited night time cooling***

Storage instead of spinning reserves

- Fast storage (at least 5 MW/second) is more effective than generally slower conventional generation in meeting the need for regulation and ramping capability
- A 30 to 50 MW storage device is as effective or more effective as a 100 MW combustion turbine used for regulation purposes. A 50 MW storage device has an approximate – 50 to + 50 MW operating range
- Use of storage avoids greenhouse gas emissions increases associated with committing combustion turbines strictly for regulation, balancing, and ramping duty.

The Virtual Power Plant (VPP) Integrates:

- **End Use Loads – (Variable Loads)**
  - Appliances, etc.
  - Heating/Cooling
  - Electric Vehicles
- **Supply Resources – (Variable Supply)**
  - Renewables (Solar, Wind)
  - Distributed Generation (Engines, Fuel Cells, etc.)
- **Storage**
  - Batteries
  - Pumped Hydro
  - Thermal storage

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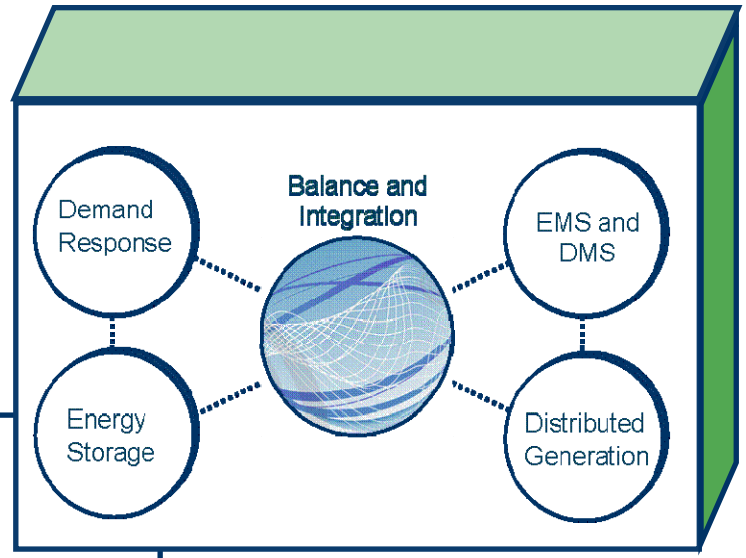
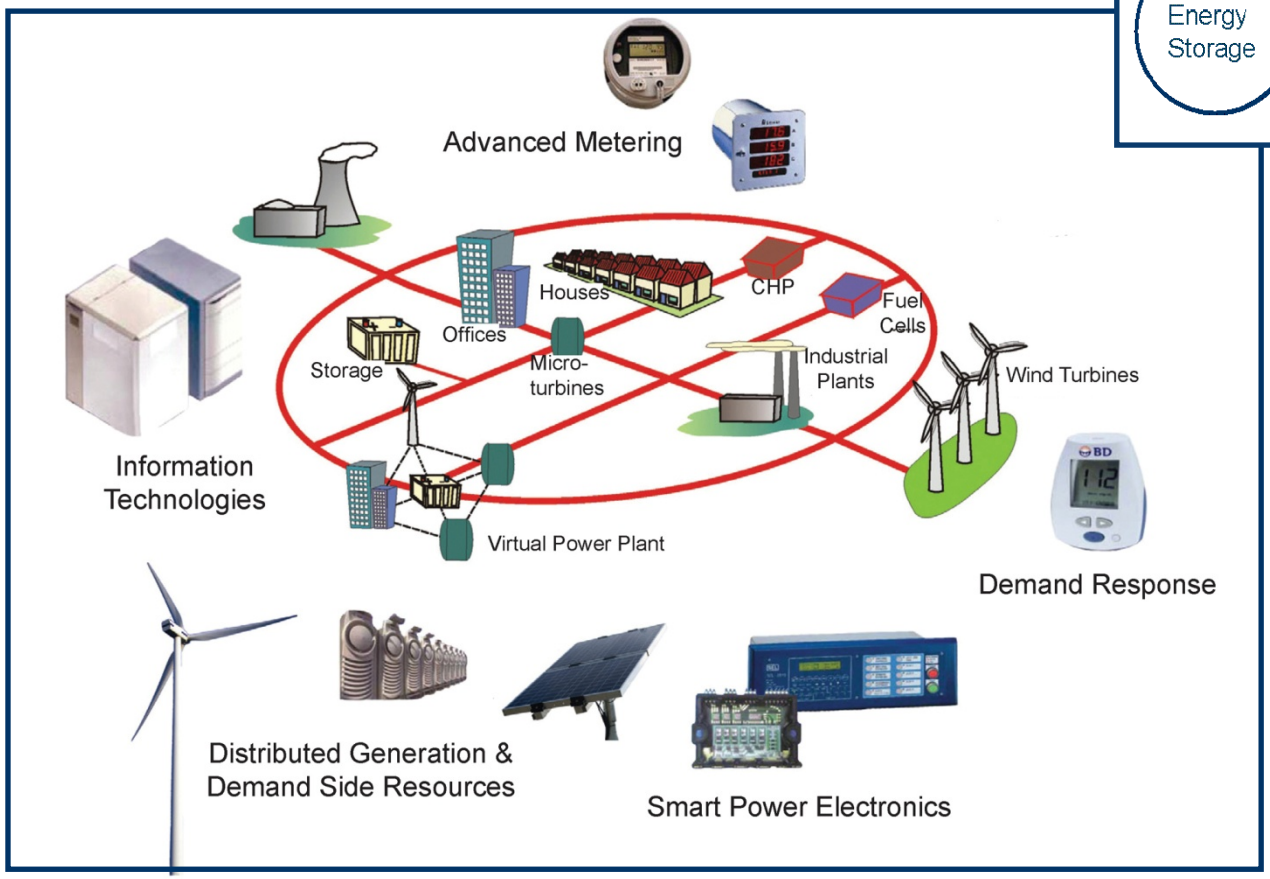
Integration with smart grid assets results in optimized – and sustainable “virtual power network”





THANK YOU!

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