Energy Storage Update

Technology and Operational Implications

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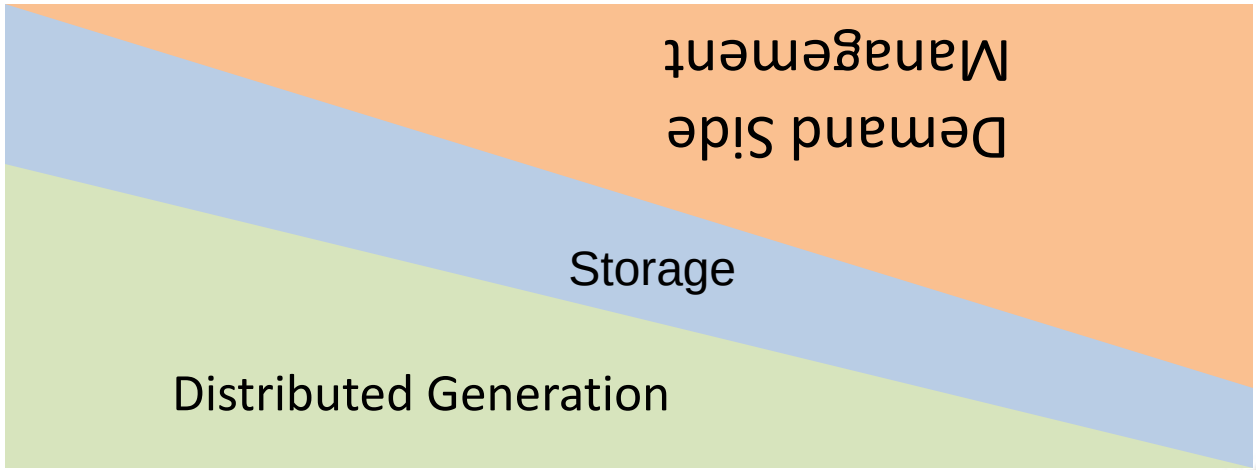
DER Continuum

- Distributed Energy Resources (3kW-20MW)
  - Generation
  - Storage
  - Distributed Energy Resources
- My comments are primarily focused on “D” not “T”



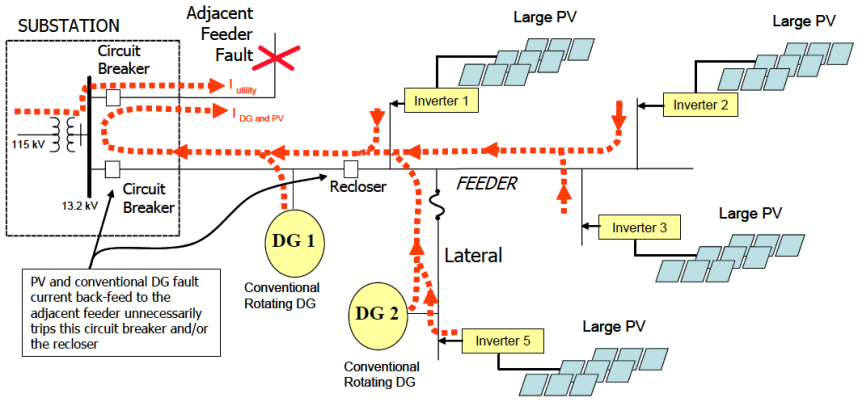
Distributed Generation Types

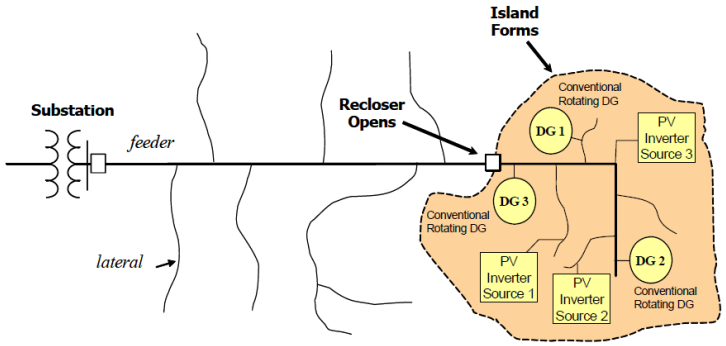
- PV
- Wind
- Natural gas fuel cell
- Natural gas Co-gen
- Biomass
- Biogas
- Diesels and Gasoline Engines
- Gas Turbines
- Small Hydro Impoundments
- Run of the River Hydro

Renewable Non-Schedulable	Non-Renewable Non-Schedulable
Renewable Schedulable	Non-Renewable Schedulable

Distributed Generation Technical Challenges

- Voltage and VAR Regulation
- Protection Coordination
- Grounding
- Power Quality
  - Harmonics
  - Flicker
  - DC in AC Networks
- Islanding
  - Unintentional
  - Microgrids
- System Control





Why Distributed Generation?

- Generate power closer to where it is used
- Customers want it
  - Green
  - Reliability
  - Cost
  - Flexibility
- Grid constraints
- Regulatory mandate/incentives

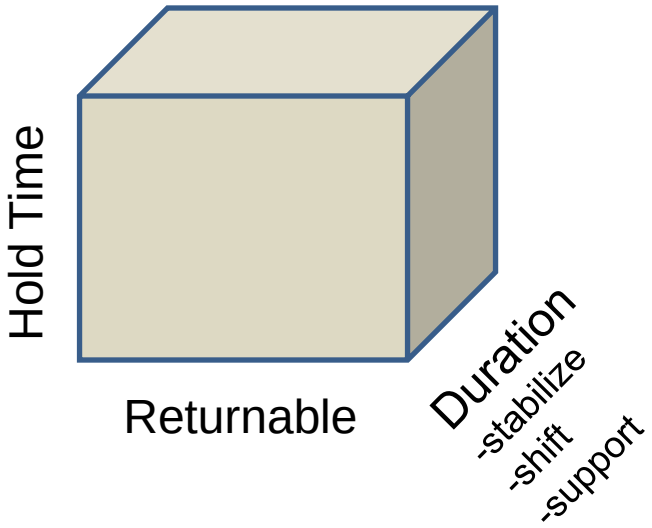
What they don't want:
-it smells
-it makes noise
-they can see it
-it changes the landscape
-it restricts their movement
-it makes the lights flicker
-it can be noticed in any way

Why Storage?

- Load varies
  - Matching peak load
- Some generation varies
  - PV/Wind are both non-schedulable except in large aggregations
- Reduce investment in peak generation
- Grid constraints
- Customer economics
- Car charging
- Home Safeguarding (Best Buy Persona Concept)

Storage Types

- Chemical / Properities of Materials
  - Batteries – many chemistries
  - Capacitors
- Thermal
  - Ice
  - Hot mass
- Mechanical
  - Fly wheels
  - Pumped Storage
  - High pressure air

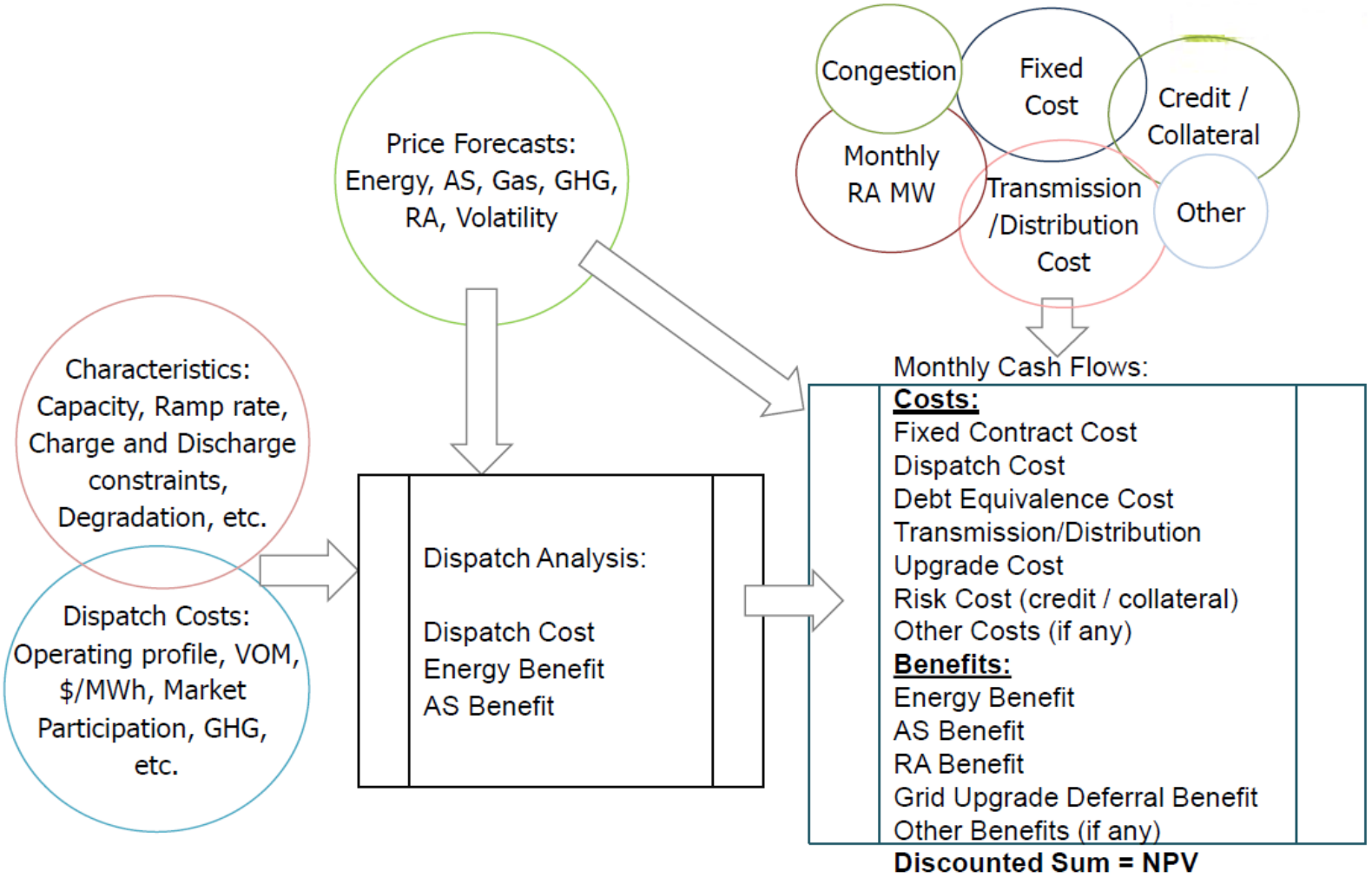


Another consideration:
-fixed or mobile

Operational Challenges

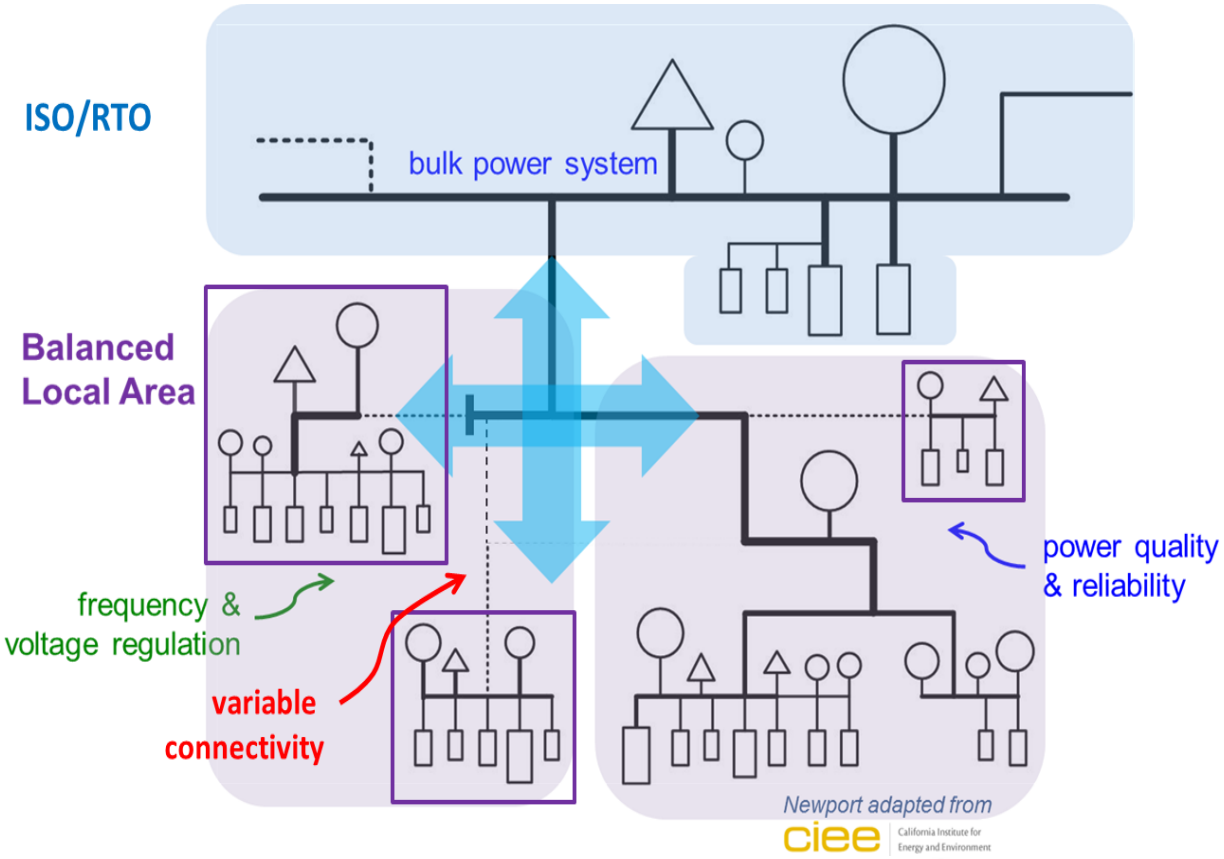
- Distributed Energy Storage Has:
  - All the operational challenges of distributed generation plus:
    - Cycle limited life
    - Complex optionality (many potential applications)
    - Challenging to optimize
    - Control complexity
    - Challenging business case
    - Often new, less proven technology as compared to other utility deployed technology for which rate recovery can be achieved

SCE Storage Valuation Process



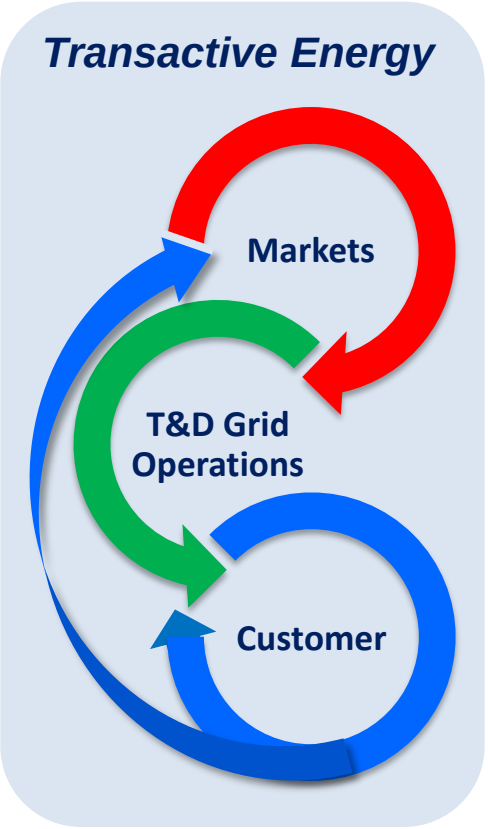
Multi-directional Power Flow

Multi-party transactions across distribution and T-D interface requires **power flow control devices**, **grid based energy storage** and **transaction management systems**



Transactive Energy:
Engineering-Economic Based Operational Controls

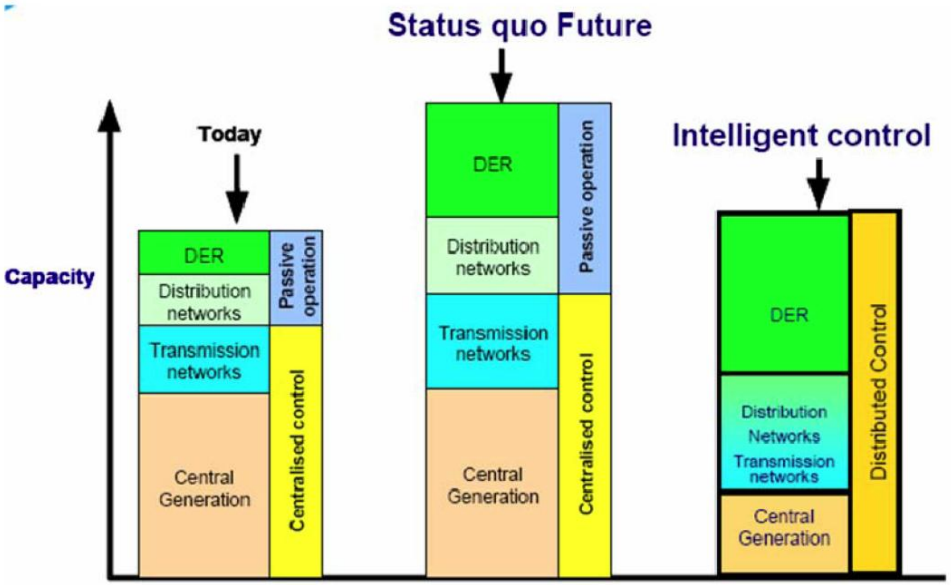
"Transactive Energy is the ability of customers and others, using value driven control systems, to optimize their use and sale of electric services to markets and grid operators to enhance economic efficiency and reliability."



- Addresses need for reconciliation of converging multi-party business and operational objectives and constraints
- Needed to properly value all forms of distributed resources (e.g. DG, Storage, DSM) based on flexibility, availability and system impact cost
- Not just markets, but also a broader integrated cyber-physical control system to ensure reliable electric services

Conclusions

- Multiple operational impacts of pervasive DER including storage
- New planning methods and tools required
- New control methods and architectures required
- New skills required for power engineers
- New economic models
- New regulatory view
- New standards needed



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