An Analytical Perspective for Evaluating Microgrid Resiliency

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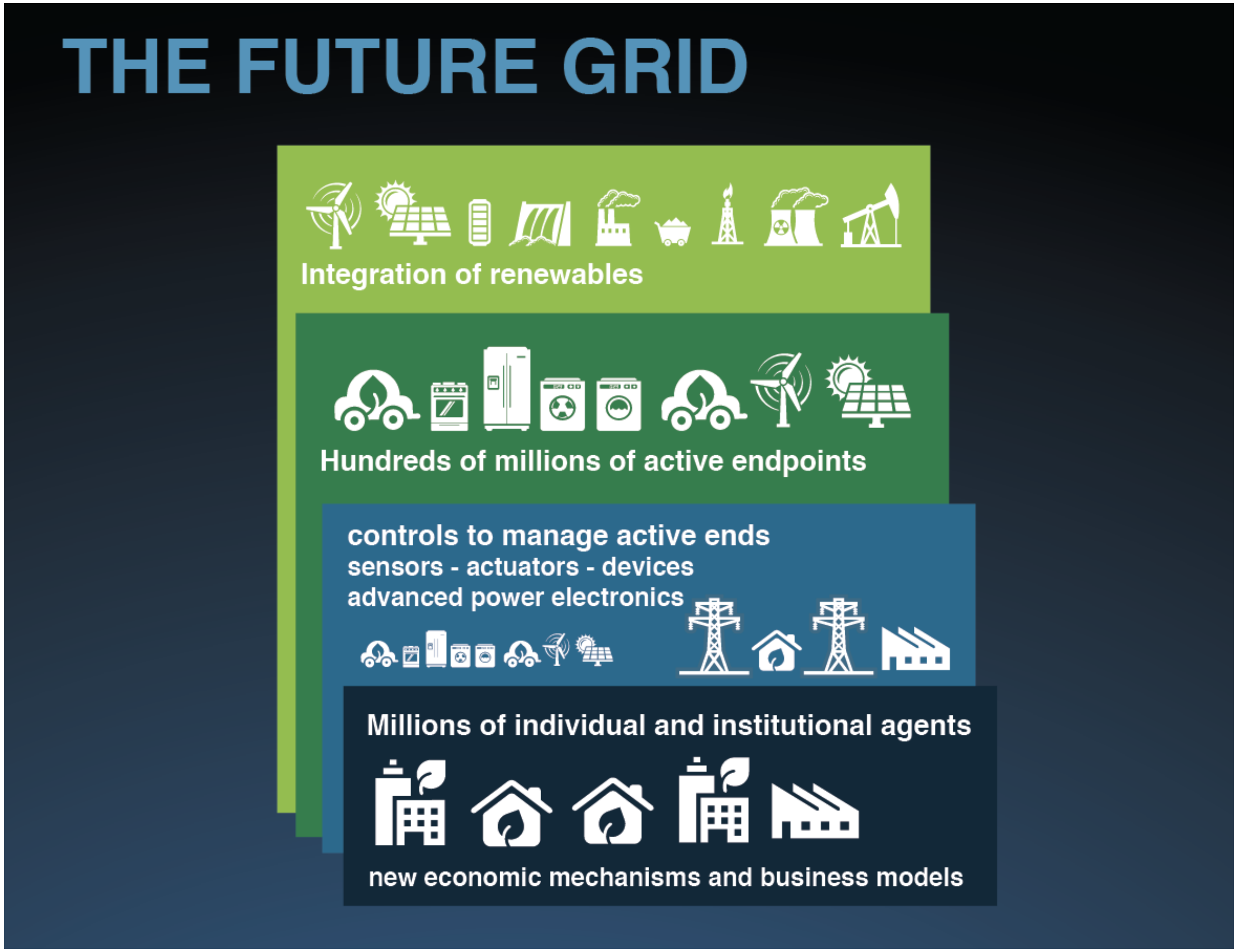
Smart Grid: Internet of things



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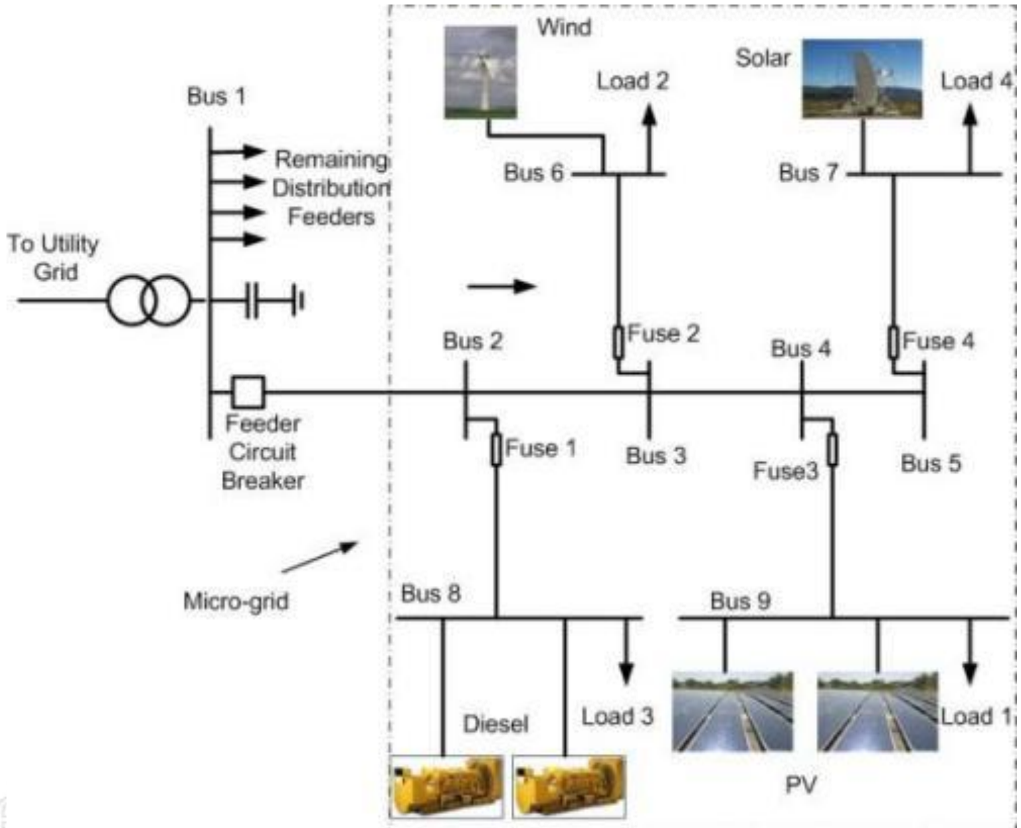
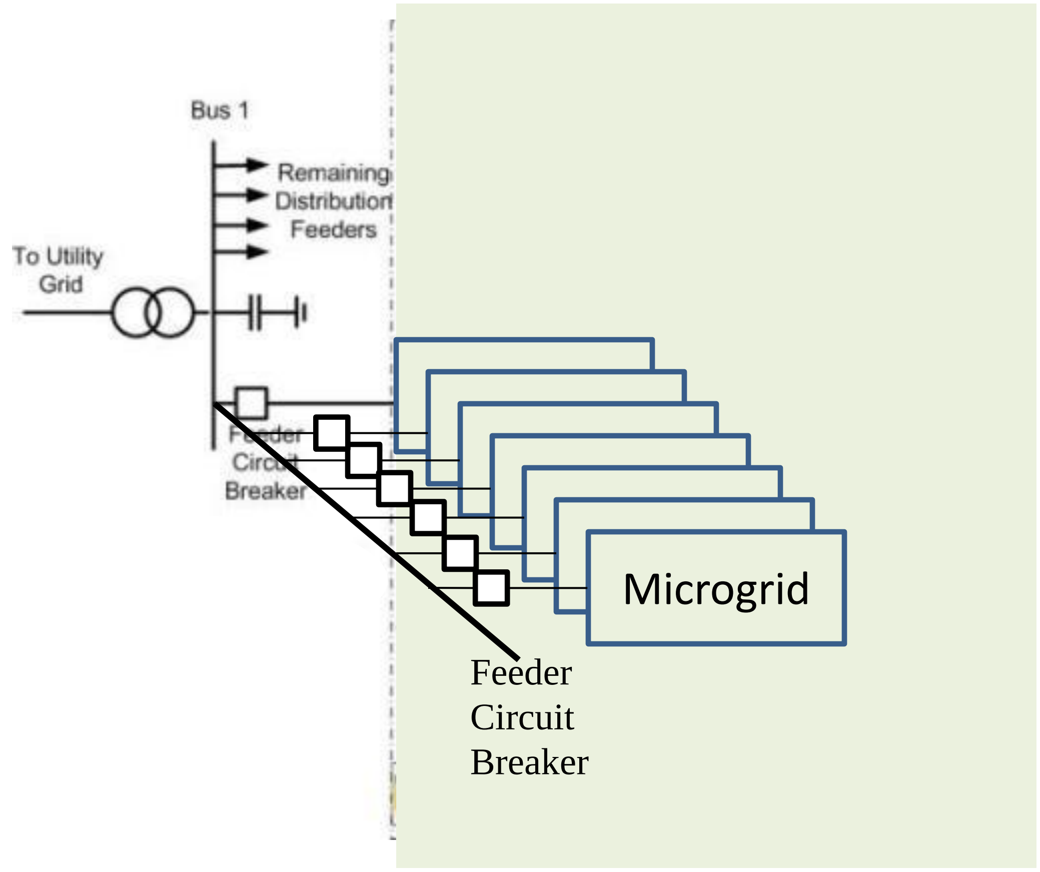
Properties of μ_{grid}

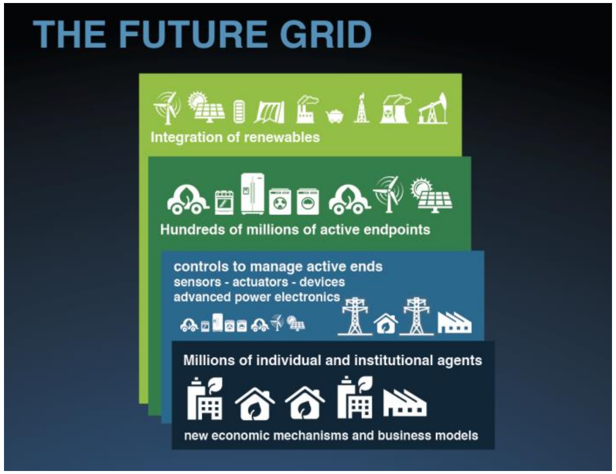
- Distributed generators with storage
- Autonomous load centers
- Operates in interconnected/islanded mode



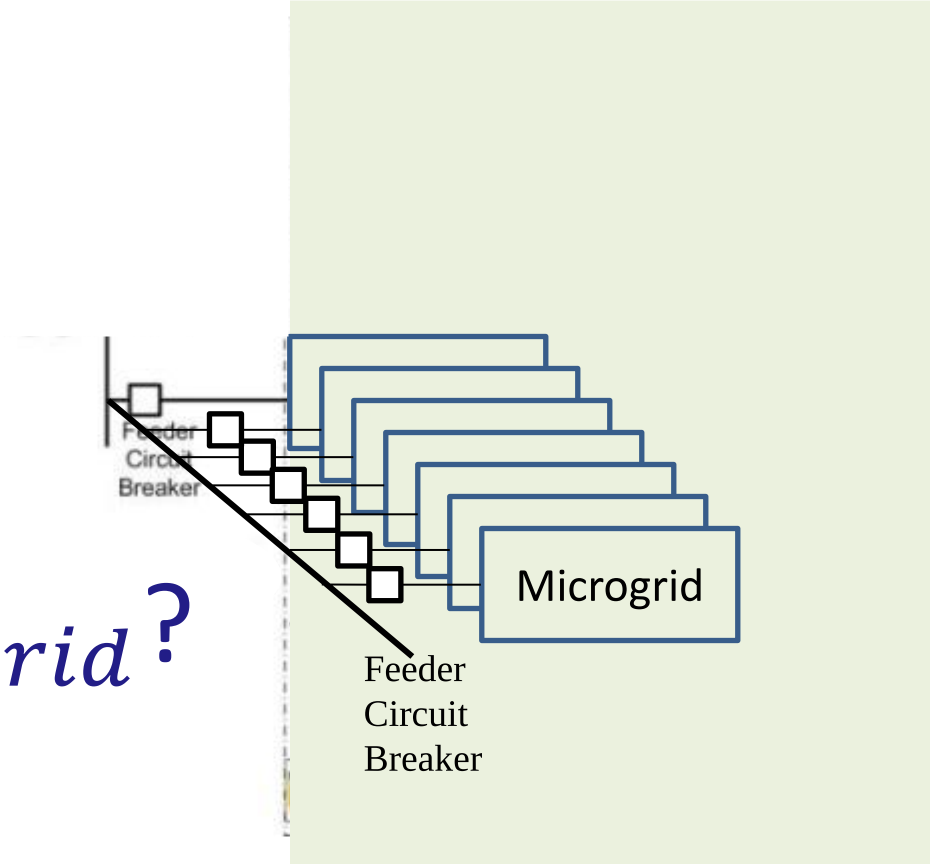
Network of Micrograms



Infinite grid



$$= \mu_{grid} + \ldots + \mu_{grid}?$$



Microgrid advantages

- Efficient integration of Distributed Energy Resources
- Access to Distributed Community Storage
- Demand Response enables a large percentage of flexible loads
- Local management of resiliency and cybersecurity
- A scaled evaluation of a smart grid paradigm

Microgrid goals

- To maintain power balance in the system.
- To ensure that operating limits are maintained
  - Generators limit
  - Tie-lines limit
- To ensure that the system frequency is constant (at 60Hz or 50Hz).
- To achieve the above with renewable energy despite intermittency & uncertainty
- Islandability

Microgrid Control

- Primary control
  - Immediate (automatic) action to sudden change of load.
  - For example, reaction to frequency change.
- Secondary control
  - Restore system frequency,
  - Restore tie-line capacities to the scheduled value, and,
  - Make the areas absorb their own load.
- Tertiary control
  - Make sure that the units are scheduled in the most economical way.
- Resilience to Islandability/Connectability

Transactive control

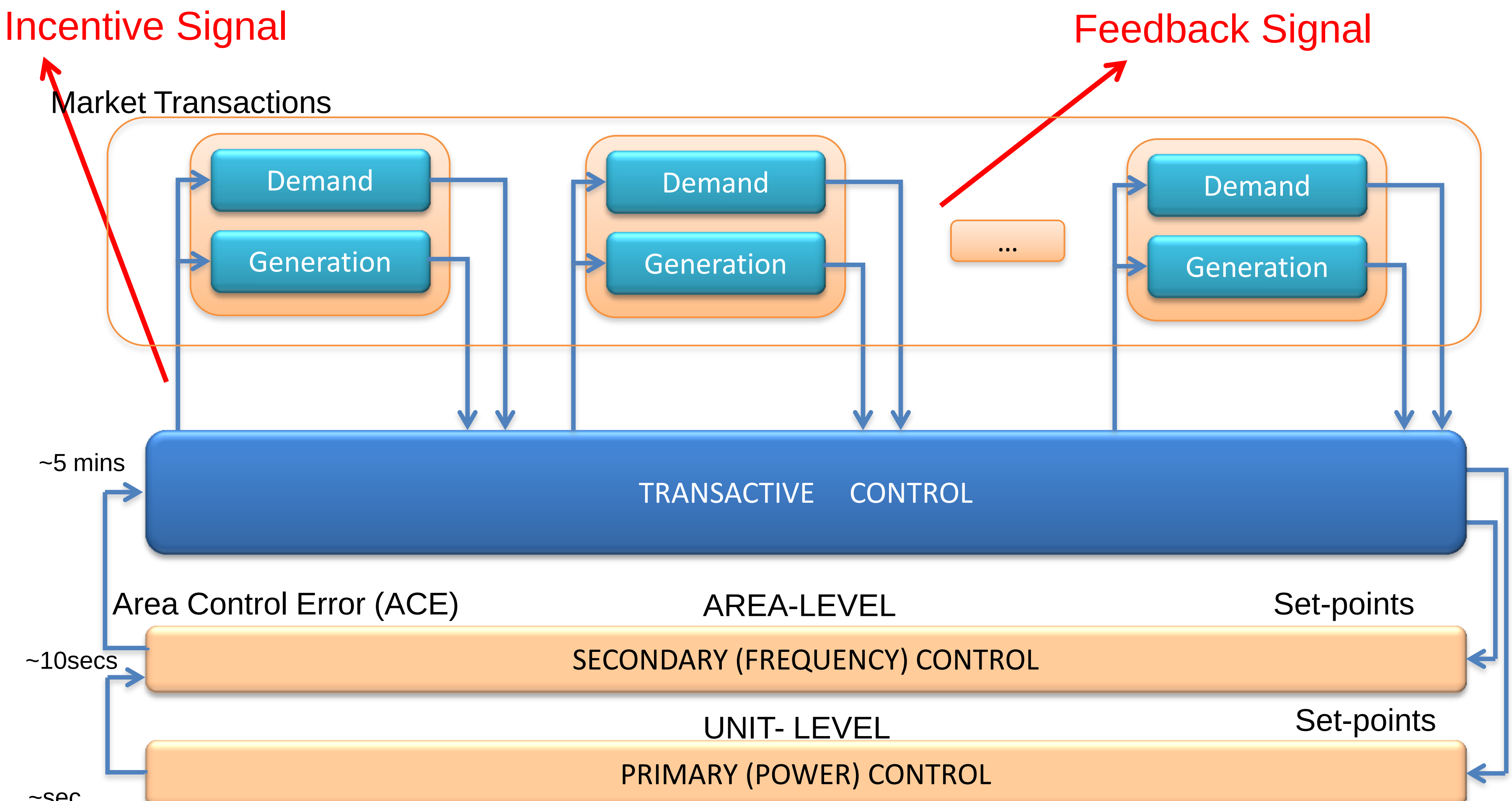
The use of dynamic market mechanism to send an incentive signal and receive a feedback signal within the power system's node structure

- Incentive Signal: Dynamic Pricing
- Feedback Signal:
  - Adjustable Demand (Market Level)
    - (Price Responsive, and Regulation Responsive)
  - Area Control Error (Secondary Level)
  - Governor Control (Primary Level)

Transactive Control → Control architecture that coordinates

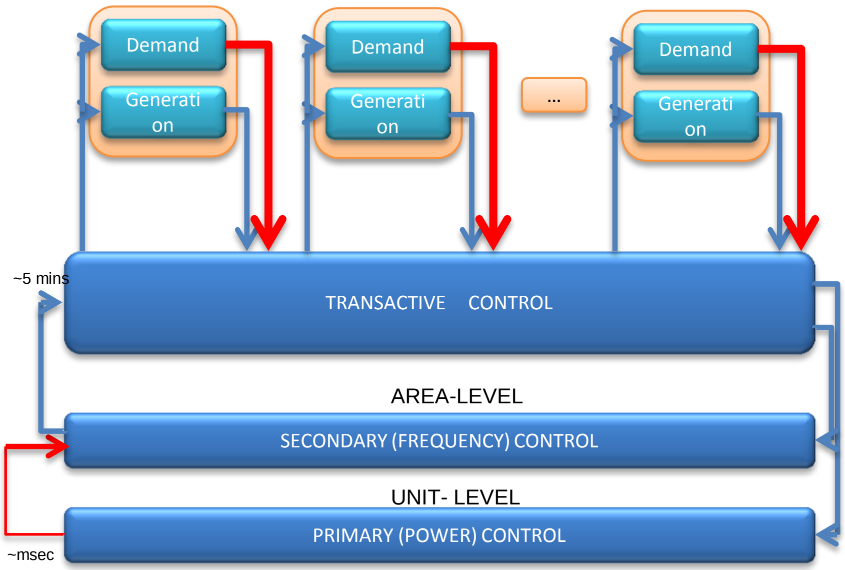
- ➢ Market Transactions
- ➢ Active Control at the AGC level with Regulation Demand Response
- ➢ Island from/reconnect to the infinite grid

Transactive Control Framework*



* A. Kiani, A.M. Annaswamy, and T. Samad, "A Hierarchical Transactive Control Architecture for Renewables Integration in Smart Grids" HYCON Presentation, 2013

Transactive Control for μ_{grid}: Challenges



- Design of the incentive and feedback signal so as to ensure
  - Power balance
  - Voltage and frequency control
  - Islanding/reconnection