

November 15, 2016



Office of Electricity
Delivery & Energy
Reliability



Emerging Grid Complexity

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View from Outer Space





Attributes of the Future Grid

- Integration of renewable and distributed resources (electric cars, smart buildings, PV, wind, energy storage, microgrids, community energy)
- Shared ownership and responsibility of the electric grid planning and operations (T, D & C)
- Multi-directional flow of energy, information and money
- Evolved model for the utility business and how it is regulated to ensure reliability, efficiency, affordability, security and innovation
- Value creation through integrated networks and convergence (smart cities)





Considerations

Policy/Institutional Considerations:

Integrated Planning	Determining Value	Industry/Business Models and Market Design	Rate Design	Regulatory Models	Policy Objectives
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Highly Coupled

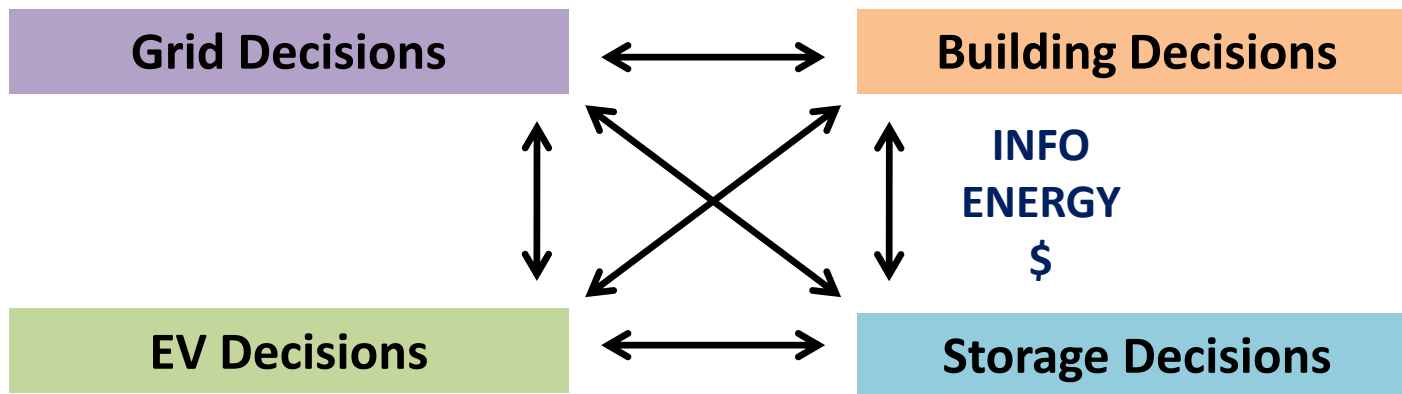
Technological Considerations:

Sensing	Communications	Control	Data/Info Management	Security (physical/cyber)	Network Convergence
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Emerging Grid Complexity

The potential of high penetrations of mixed DERs presents an entirely new problem in control, coordination and value-determination within distribution systems



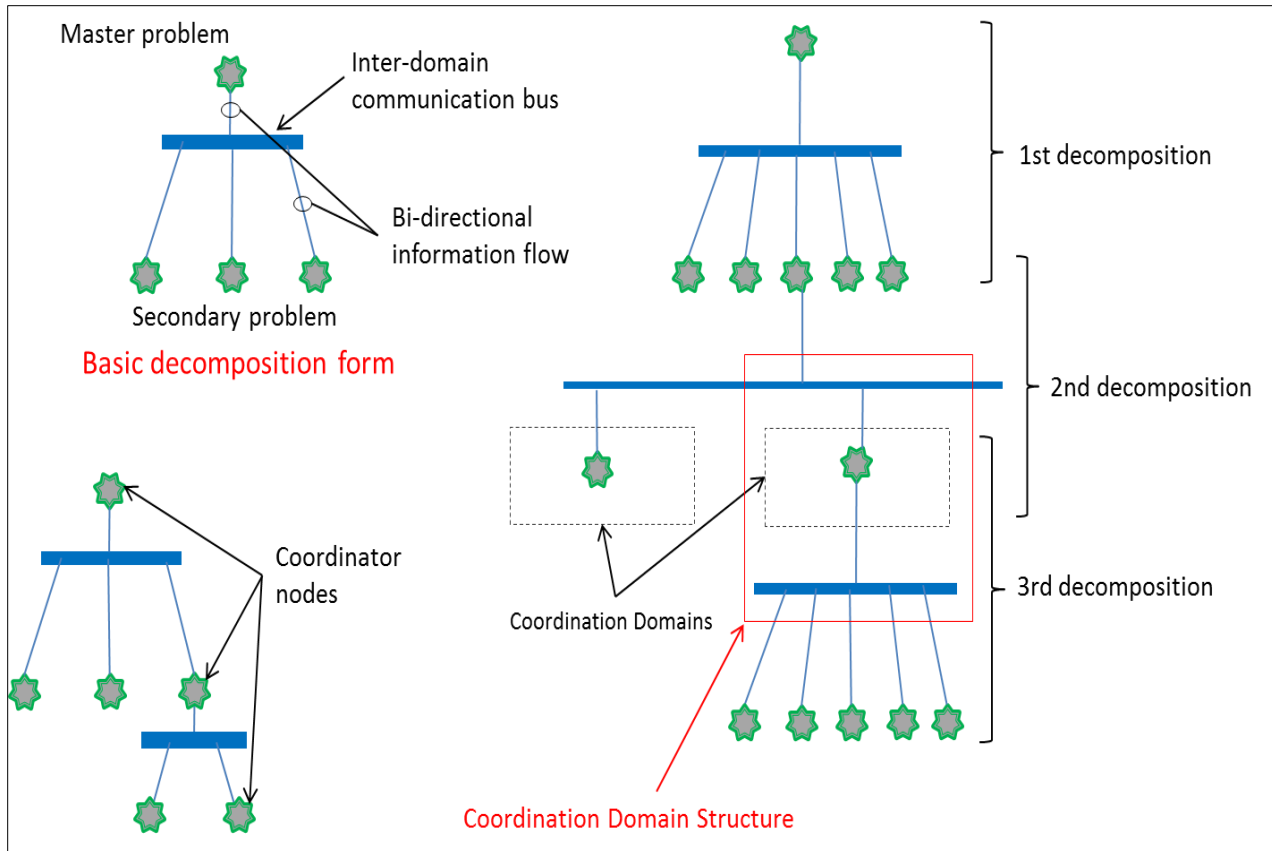
Considerations:

- Structures: electric infrastructure, ICT, control, industry, regulatory
- Optimization: local & system, centralized & distributed control
- Convergence: grid/ICT/buildings/transportation/city infrastructure
- Markets: open access networks, platforms



Coordination Considerations

Laminar Coordination Framework



From JD Taft, Architectural Basis for Highly Distributed Power Grids: Frameworks, Networks, and Grid Codes, PNNL-25480, June 2016



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PNNL Grid Architecture Website:

<http://gridarchitecture.pnnl.gov>

LBNL Future Electric Utility

Regulation Series Website:

<https://emp.lbl.gov/future-electric-utility-regulation-series>

