Grid Architecture for Buildings

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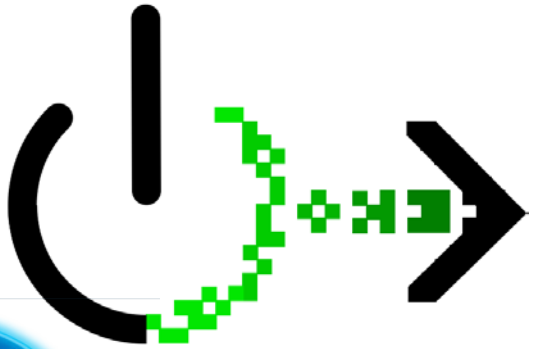
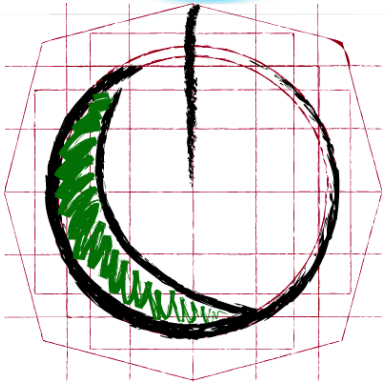
From Oct 2017

Themes

- IT
- Architecture
- Networks
- Communication
- Buildings
- Bottom-up
- Microgrids
- Fundamental Principles





“The Fit Grid” - nordman.lbl.gov

From Oct 2017

Scope

- The relationship between the building* and the grid
  - *“Building” can be commercial, residential, industrial, …. — a customer

Lots of activity

- The grid structure internal to individual buildings
  - Microgrids

Not ready for analysis

From Oct 2017

My take on Grid Architecture

- Analyze systems to distill their essence
- Draw con
- Use this i

Tensions

- Existing v
- Universal
- Existence

Assumptions

- Big changes can happen
  - Internet, electri
- Important to wo
- IT network tech
- Not all of today'
  - Business mod
- Some essential

Buildings perspective

- Delivering occupant services is **primary**
  - Using electricity a resource input - 100 : 10 : 1
- Privacy / security important

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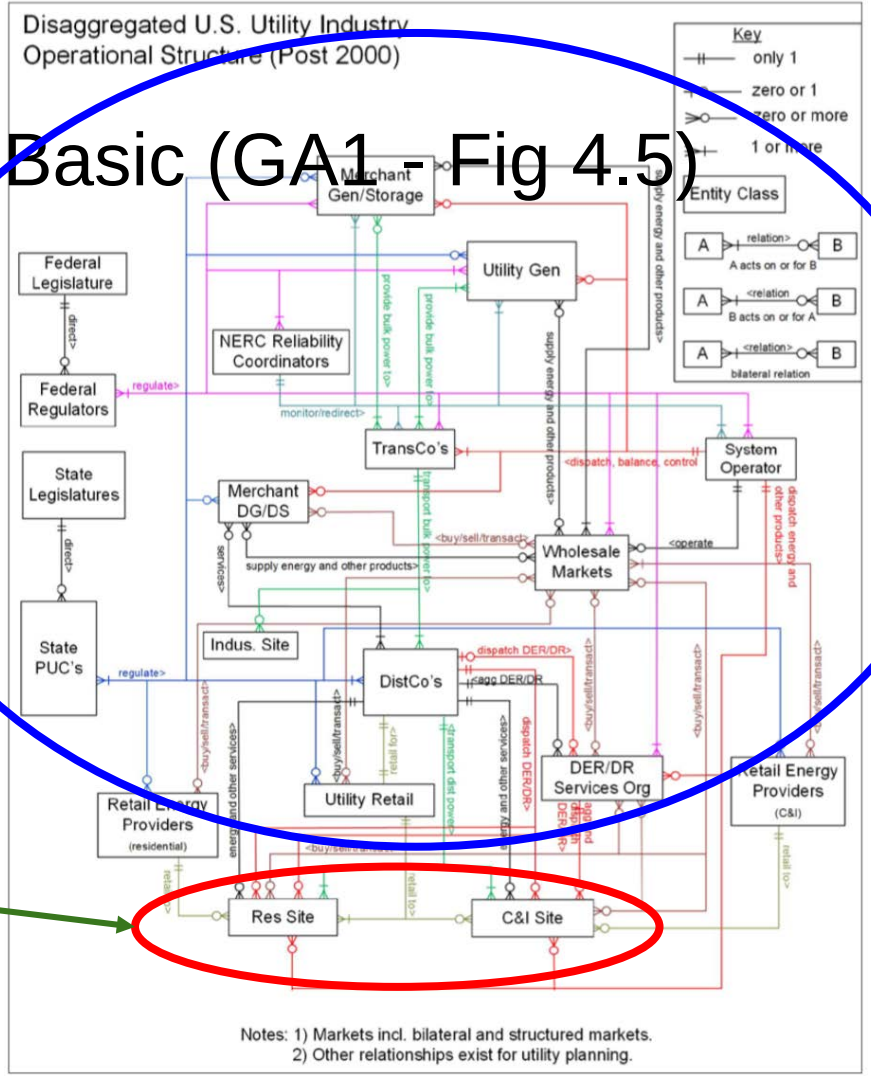
Buildings in Grid Arch. - Basic (GA1 - Fig 4.5)

"The Grid"

("The Utility Grid")

Buildings



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Buildings in Grid Arch. - Basic (GA1 - Fig 4.5)

Power

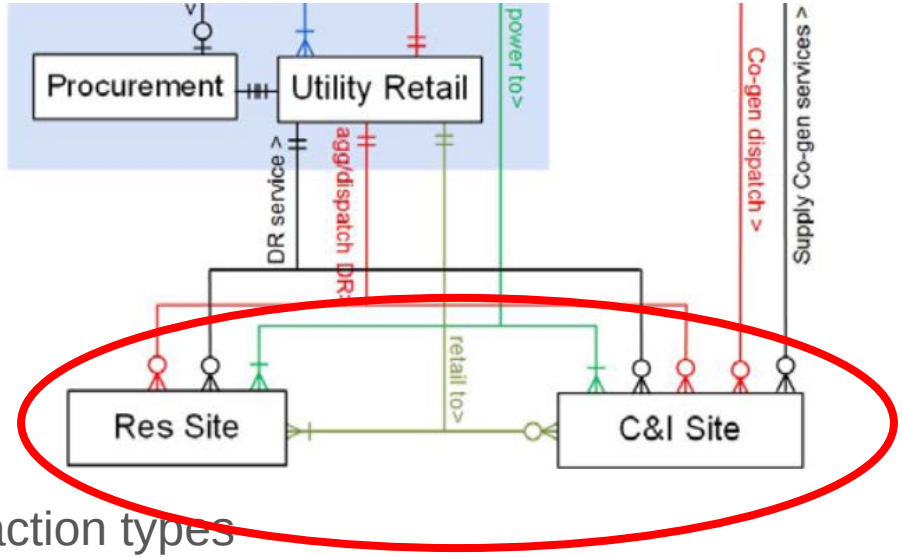
- In (Out): Electrons
- Out: $$$

Demand Response (optional)

- In: DR signals
- Out: Resulting DR services

Cogen (C&I only; optional)

- In: Dispatch
- Out: Cogen services



Interaction types

- Electricity
- Communication (control; status)
- Cash (tied to control)
- Tariff, other contracts

where is meter?

Core Issue

How to coordinate DER operation with the grid?

Today's methods

- No coordination
- Traditional DR - uniform events, baseline
- Prices CPP, TOU, highly dynamic
- Aggregator

What methods should we consider for the future?

How do we understand / analyze these methods?

Price-based Grid Management (PBGM)

- Could not find method for neutral analysis of alternatives
  - Analyses all based on (unstated) underlying assumptions about what is possible / desirable
  - Frames of reference not compatible
  - Inherently multiple, diverse goals to work towards
- Method
  - Outline assumptions, goals
  - Present system that derives from those
  - Consider alternatives in relation to that system
- Goals / Principles
  - Learn from Internet Arch.
  - Simplicity
  - Plug-and-play DER
  - Inexpensive Microgrids
  - Efficiency / DC power

- Network Power Integration (NPI)

Internet Technology Design Principles

Constant Change
- Just because a mechanism has been used in the past does not mean it is necessarily a good choice for the future.

The End-to-end Principle
- "... certain required end-to-end functions can only be performed correctly by the end-systems themselves."
- A simpler network makes it more resilient to disruption, change, segmenting, and security challenges.

Heterogeneity
- There will inevitably be multiple physical layer and application layer protocols, to serve different purposes.

"If there are several ways of doing the same thing, choose one"

Scaling
- Technology that can scale up or down in electrical capacity or network size are preferred.

Performance
- A system which can do anything may have cost and complexity burdens which make it less preferred to a simpler one which does somewhat less but well-covers the most useful capabilities.

Keep it simple
- Complexity costs money and is generally worse for privacy and security than simpler systems.

Modularity is good
- If you can keep things separate, do so.

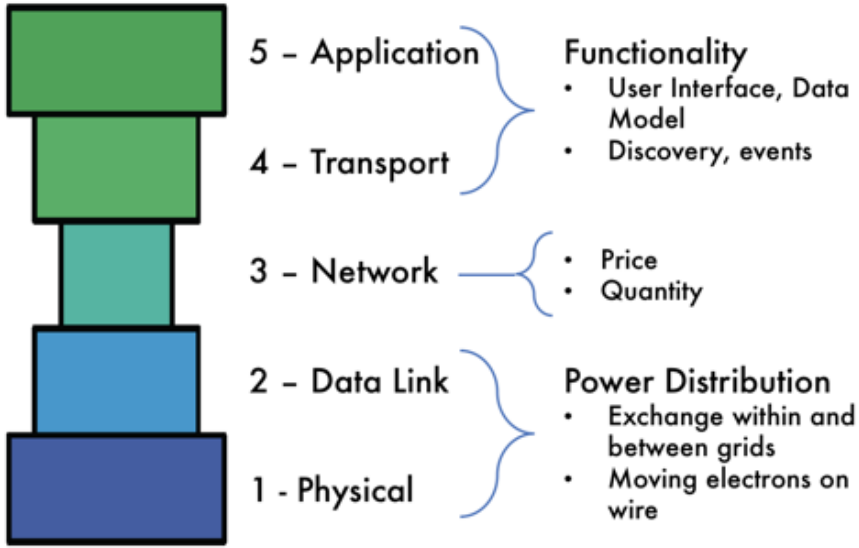
Practicality
- "In many cases it is better to adopt an almost complete solution now, rather than to wait until a perfect solution can be found."

Prefer unpatented technology
- Open standards are best.

Privacy
- This and related goals should be always addressed by end systems, whether or not the network also provides this.

Network Power Integration (NPI)

- Analogous to OSI model
- Separates technologies for power distribution from those for functional control
  - Allows parallel evolution
  - “Narrow waist of interoperability” occurs internally to each device
- Only applies within buildings



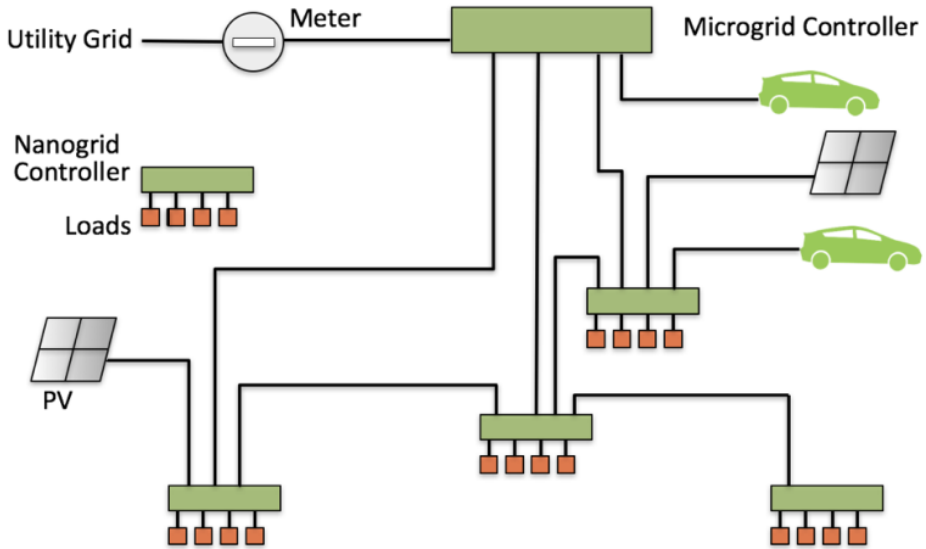
“Local prices”

Many reasons prices in building may differ from grid price

- Differential buy/sell prices
- Carbon valuation
- DC circuits
- Peer-to-peer exchange
- Microgrids
- Capacity constraints
- Battery management

Local prices facilitate networked power

- Local Power Distribution



Pricing applied

Pricing can do most of what is needed for DER coordination

- Should make maximum use of prices before adding complexity

Price is a control signal

- In addition to having revenue implications

Prices manage energy - not capacity or power

- Need other mechanisms for these, e.g. for vehicles, inverters

Price is a unit of measurement

Pricing **is** transactive energy

Other methods

	One-Way Communications	**Two-Way Communications**
Decisions on Local Issues Made Locally	Price Reaction + Full Use of Response Potential – Uncertain System Reaction – Market Inefficiency + No Privacy Issues	Transactive Control + Full Use of Response Potential + Certain System Reaction + Efficiency Market + No Privacy Issues
Decisions on Local Issues Made Centrally	Top-Down Switching – Partial Use of Response Potential – Uncertain System Reaction – Autonomy Issues	Centralized Optimization + Full Use of Response Potential + Certain System Reaction – Privacy and Autonomy Issues – Low Scalability

Source: Kok and Widergren, 2016

Other methods

	One-Way Communications	Two-Way Communications
Decisio Local Is Made Locally		tial
Decisio Local Is Made Central		tial es

Comments

- Only considers Grid perspective
  - Except to acknowledge privacy / autonomy
- Does not consider burden of complexity
- Assumes one-way pricing can't get to correct price
- Assumes important for coordination to be deterministic at building level
- "Central" has different meaning for utility and building
- Doesn't distinguish between coordination with whole building or each DER
- Doesn't cover traditional event-based DR

Source: Kok and Widergren, 2016

Other methods in comparison to pricing

Traditional DR (single DER; defined size/duration) is inferior

- Requires separate coordination for each DER
- No flexibility in size/duration
- Verification cumbersome, limited

Central Optimization (one- or two-way) is implausible

- Good performance requires exporting building operational details
- Exporting building operational details creates privacy/security problems

Both inevitably leave out many loads

Only Two-way Transactive could perform as well as Pricing

Pricing (PBGM) vs. Two-way Transactive (TWT)

Performance: TWT vs PBGM

- Either could be better but likely similar; empirical question

TWT

- Requires same functionality/cost tradeoff as pricing ...
- … but also requires forecasting/commitment
- Requires new mechanisms all over: regulatory, building/grid, intra-building
- Transition process unclear
- Brittle

TWT can be with central grid entity

- Is this just another way to get to the right price?

TWT can be peer-to-peer

- What is value of P2P over central clearing?

Pricing (PBGM) vs. all other methods

All non-PBGM schemes

- Value some electrons at same place/time differently
- Don’t directly facilitate operation when electrically islanded
- Don’t directly facilitate operation with communications loss
- Don’t address issues that local pricing does

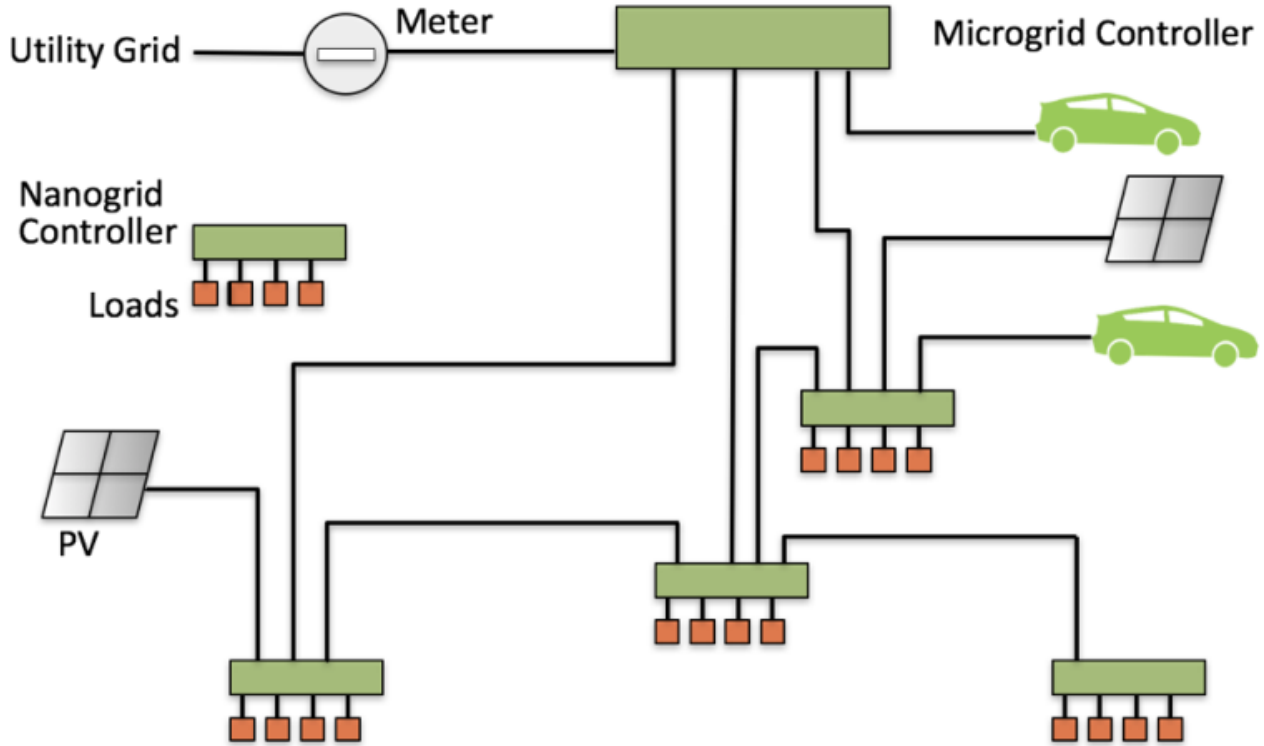
Relation to 5 Tracks

- Advanced Bulk Energy Systems
  - None
- High Resilience Grid
  - Little about buildings specifically; many principles well-apply to buildings
  - Need to consider inter-LEN interfaces vs. grid/building interfaces
- High DER/High Automation Distribution Grid
  - Architecture abstracts DER out of buildings
  - Could consider building/customer as a single DER for grid coordination purposes
- Microgrids and Distribution Grid Segmentation
  - Awaiting content; DGS covered in High Resilience
  - Single-customer microgrids vs. multi-customer microgrids - very different
- Urban Converged Networks
  - Awaiting content; could apply dynamic pricing to other forms of energy

How you can help

- Provide feedback on this presentation
- Review draft paper - Grid Architecture for Buildings
- Suggest good references on DER coordination models
- Post initial content on Microgrids and Urban Converged tracks

Thank you


Utility Grid
Meter
Microgrid Controller
Nanogrid
Controller
Loads
PV