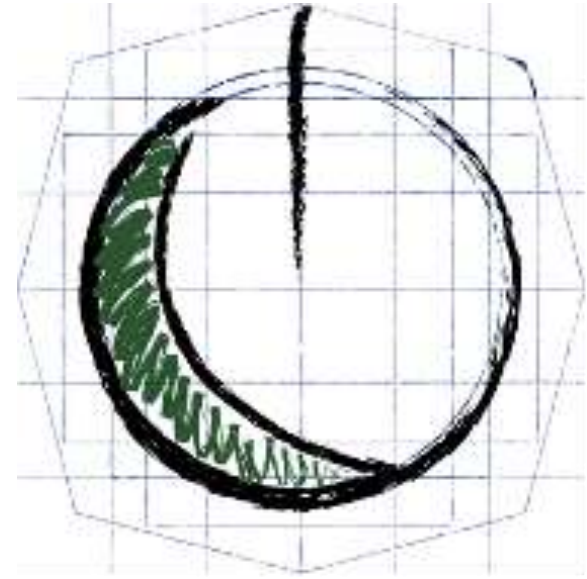


# Why Prices Must Be the Fundamental Mechanism for Electricity Coordination

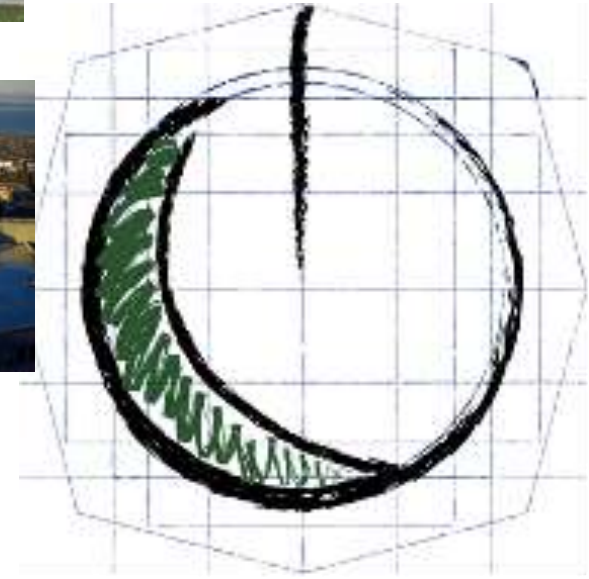
Bruce Nordman

April 23, 3026



# My Background

- Silicon Valley (IT)
- Architecture (Design)
- Energy & Resources (interdisciplinary)
- LBNL
  - Building Energy Efficiency
  - Electronics Energy Efficiency
  - Networks / Electricity
  - Networking Electricity
  - Demand Flexibility
- Now



# My Approach

## Customer first

- The grid should be designed around customer needs first ...
- ... but also workable for the grid
- Flexibility is mostly about machines (appliances), not people

## Technology-centric

- We are in a time of transition - *“leaps not tweaks”*
- New technology has fundamentally new capabilities - mainly in buildings
- Start from future - work backwards to present
- Policy / Regulation / Tariffs - derive from technology

# Clarification/Assumptions

- VPPs and programs are always optional  
Having a tariff (prices) is never optional (even if flat)
- VPPs should be able to compete with pricing
  - Competition must be fair - people must have access to good prices\*
  - VPPs need to be layered on top of pricing - not a substitute for it
- Niche services are not amenable to pricing
  - e.g. emergency load drop, regulation services
  - They will increasingly be delivered by grid-scale batteries
- VPPs (and programs) must be optional
  - Customers must always have the option to manage devices themselves
  - Required for privacy and autonomy

*\*Good prices are good for customer and good for the grid;  
They can produce best result for grid*

## Clarification/Assumptions (2)

- Customer should be a black box to the grid - and vice versa
  - Utilities think they need to peer inside the customer site for operational purposes
  - They are wrong (planning might be different)
- It is the job of customer devices to respond to prices that are best for the customer
  - Customer amenity is primary
- It is the job of the grid to offer prices which are best for the grid
  - Maximize renewables use
  - Minimize costs
  - Respect T/D constraints

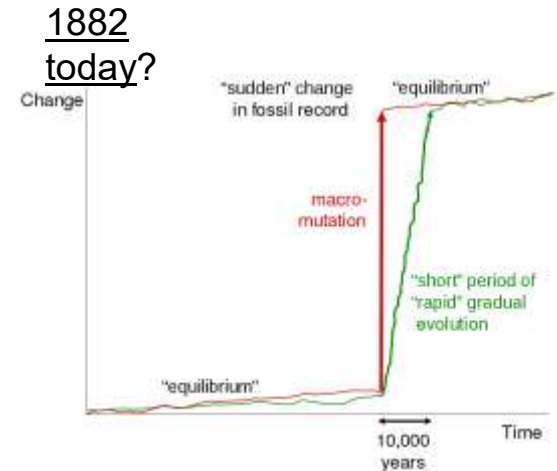
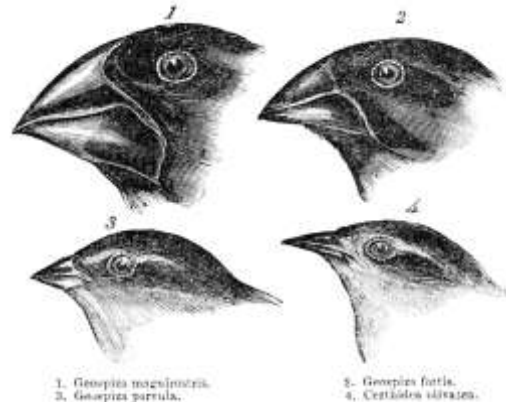
***Setting a good retail price is a basic function of any business***

- Capacity management - in coordination with customer - *“size of the pipe”*
  - Will inevitably be needed w/ or w/o VPPs
  - Operates in parallel with and is complementary to pricing

# Punctuated Equilibria

- evolutionary biology
- “... once a species appears in the fossil record, the population will become stable, showing little evolutionary change for most of its geological history.”
- Stasis
- Discontinuity (or "sudden jumps")

Source: Wikipedia



akin to 'paradigm shifts' as with Thomas Kuhn *The Structure of Scientific Revolutions*

# “Unitary Grid” - single ‘pool’ of power



- Buildings and all devices part of the pool

It used to be important to think of the grid as extending to each load.

# “Modern Grid” - customers are adjacent domains of power



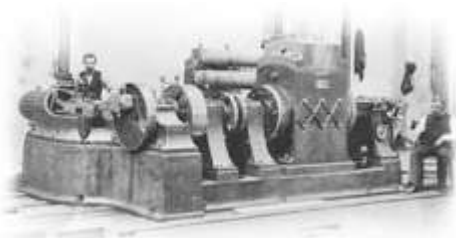
- ~~Buildings and all devices part of the pool~~

It used to be important to think of the grid as extending to each **load**.

In the future (and present) it is important to understand that the grid ends at the **meter**.

# Power Distribution – 143 years later

## Generation



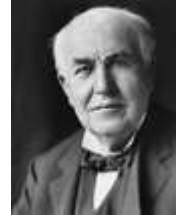
## End Use



## Wide area Distribution



## Local area Distribution



Thomas Edison

- Wires
- ~~Fuses~~ Circuit Breakers
- Junction boxes
- ...



Over 10 years since I first used this slide!

# The “Whys” - ... Prices Must Be the Fundamental Mechanism ...

- Prices are how markets work
  - They need to be good prices
  - Bad prices ... are bad data ... and produce bad results
- Lessons from Internet technology
  - The best things in life are Simple and Universal
- Pricing is **only** mechanism that can work
  - in any country
  - at any scale
  - in any context

***No Other Mechanism can have these characteristics***

# The “Whys” - ... Prices Must Be the Fundamental Mechanism ... (2)

## Local Prices

*The value of electricity inside the customer site can diverge from the price at the meter*

- Basic example - asymmetric prices
  - Import price: \$0.40/kWh; export price \$0.08/kWh
  - If site is exporting, water heater uses 8 cent electricity
- Price is a unit of measurement
- It can be used in cash exchange - or otherwise; just like meters and kg
- **Local prices** are increasingly important
  - It can be difficult or impossible for VPPs to know what the local price is
  - Inevitable conflict between VPP interests and customer interests
  - Not surprising when three different parties have diverging interests
- Aggregators are expensive and low-performing
- If system is fair, pricing will produce lower bills

# Highly Dynamic Prices (HDP)

## Definition

- Intervals between **hourly** and 5 minutes
- Set no farther in advance than the day before
- **Different every day**

*Necessary conditions to be responsive to actual grid conditions*

**NOT “RTP”**

## Components

- Electricity **prices** for a forecast period, usually 24 hours
  - May be guaranteed or best-effort
- May include a parallel set of **export** prices

## *Non-financial*

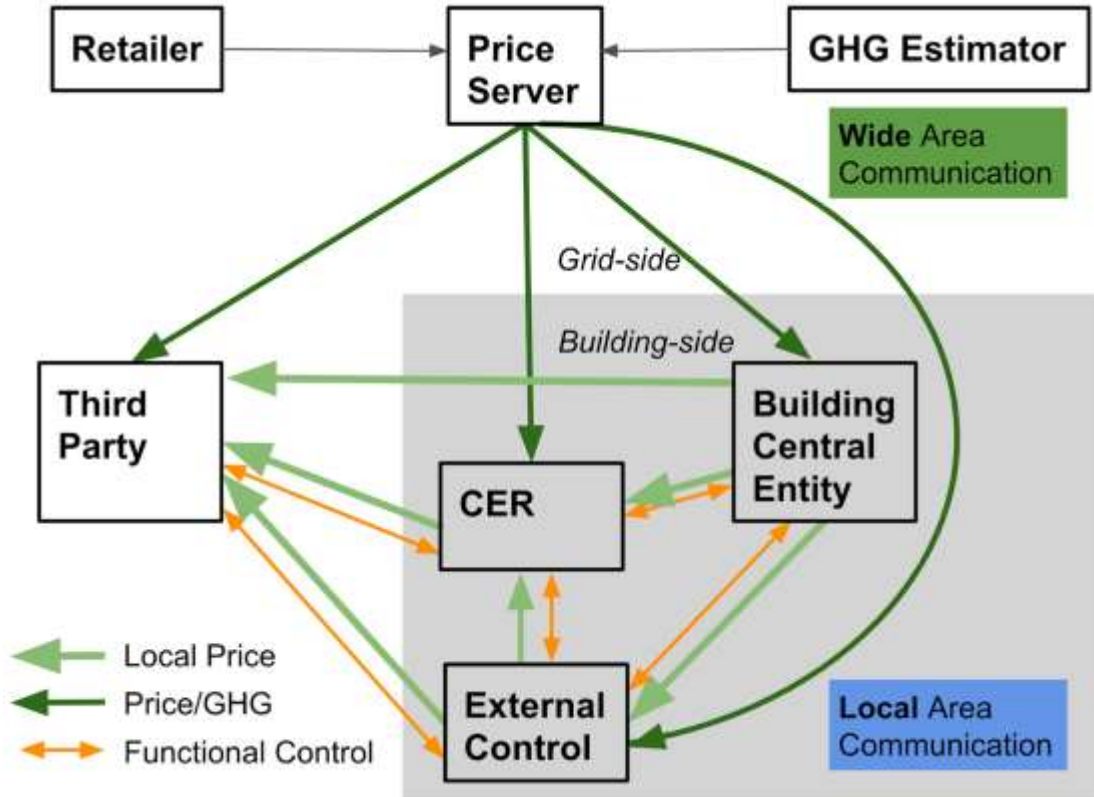
- Marginal **GHG** emissions forecast (also intervals)
- Very occasional **alerts**
  - Grid emergency, PSPS, wildfire, tsunami, air quality, ...

***Thats it!***

# How does dynamic pricing work?

- **Utility offers** a good price
  - Provides enough value to customers (e.g. enough dynamic range)
  - Results in notably lower bill than alternatives after reasonable shifting
  - No problematic features (e.g. demand charges)
- **Utility publishes** price with a Price Server
  - OpenADR 3 used consistently
- **Communication** protocols carry prices to where used
  - Standard Internet communication
- **Optimization** changes device behavior
  - Device, local controller, EMS, cloud

# “Price-Based Grid Coordination” (PBGC)



- Data flow to CER / customers is one-way
  - Return is measurements from feeders, substations, ...
- Allows innovation in how to determine prices and how CER use them
- Enables multiple locations of translating prices to functional controls
- Building ‘gateway’ not required
  - But really useful

# Next Steps

- Adopt HDP concept, terminology, system architecture
- Use consistent/standard protocolsL OpenADR 3, Matter
- Retailers offer good prices
- Manufacturers will begin to offer optimization
  - New products
  - Software updates to existing
  - Cloud-based
- Others will begin to offer optimization
  - Energy Management Systems
  - Dedicated controllers
  - Cloud-based
- Number of price-responsive customer devices will continuously grow
- System costs and customer bills decline; more renewables / storage integrated

*Thank you*



# Local Prices

- The *value* of electricity inside the customer site can diverge from the price at the meter
  - Price is a unit of measurement
  - It can be used in cash exchange - or otherwise; just like meters and kg
- Examples
  - Asymmetric import / export prices
  - Addition of GHG burden
  - Microgrid operation
  - DC power domain
  - Capacity constraint at meter
  - Internal capacity constraint
  - Local generation
  - Peer-to-peer exchange