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BIG DATA & ANALYTICS PLATFORM FOR THE ENERGY INDUSTRY

CHRIS KNUDSEN

CHIEF TECHNOLOGY OFFICER

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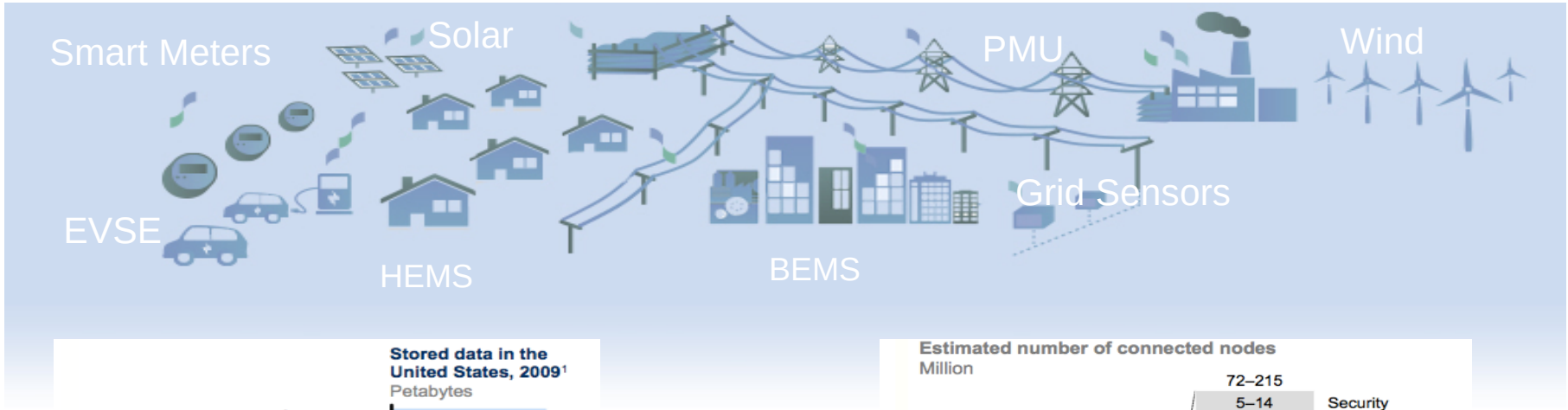
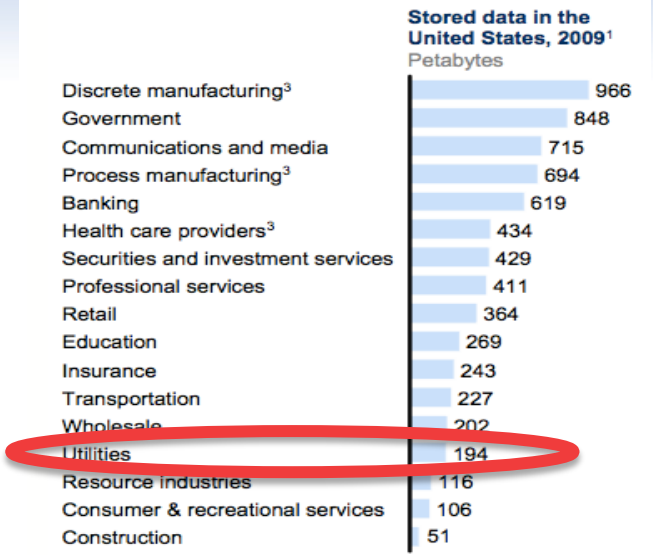
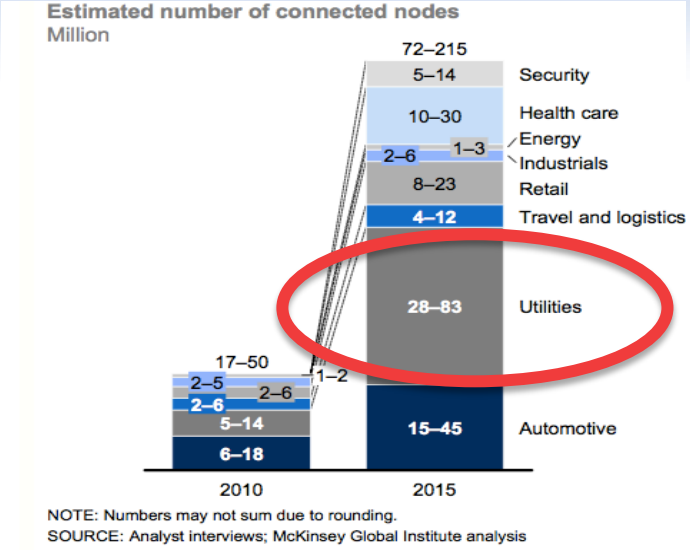
Setting the context of this discussion

- AutoGrid was founded in 2011
  - AutoGrid set out to solve the big data problem for the Energy industry. I will discus what I think that means?
  - Winner of APRA-E GENI project for “Highly Dispatchable and Distributed Demand Response for the Integration of Distributed Generation”
- What are we doing
  - Massively scaling, cloud, big data, analytics platform for the Energy Industry
  - Constraint => need to be profitable in VC time horizon,
    - so not an academic exercise
    - Driven by applying solution to pragmatic issues that drive revenue
  - Time Series Data Driven
  - Granular / Bottoms Up
  - So Not focused on Transmission but Transmission can be a dynamic group
  - Groups / static and dynamic
  - Designed for Scale

It is well known that Utility data sets are growing fast (TB->PB)





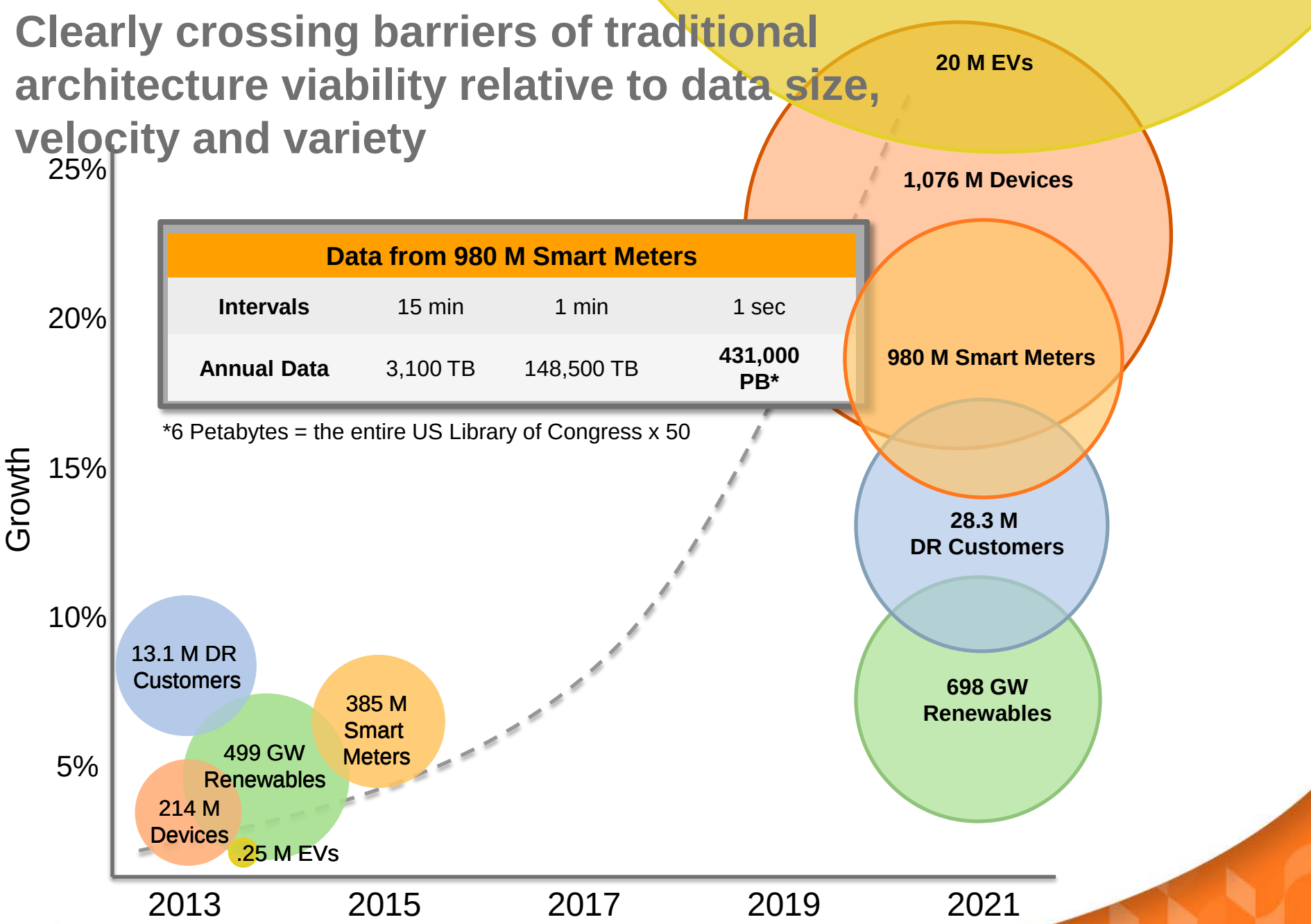


Utilities have traditionally been amongst the lowest data intensity companies…

…yet they are dealing with more data coming from more connected nodes than any industry.

Source: McKinsey Global Institute report.

Clearly crossing barriers of traditional architecture viability relative to data size, velocity and variety

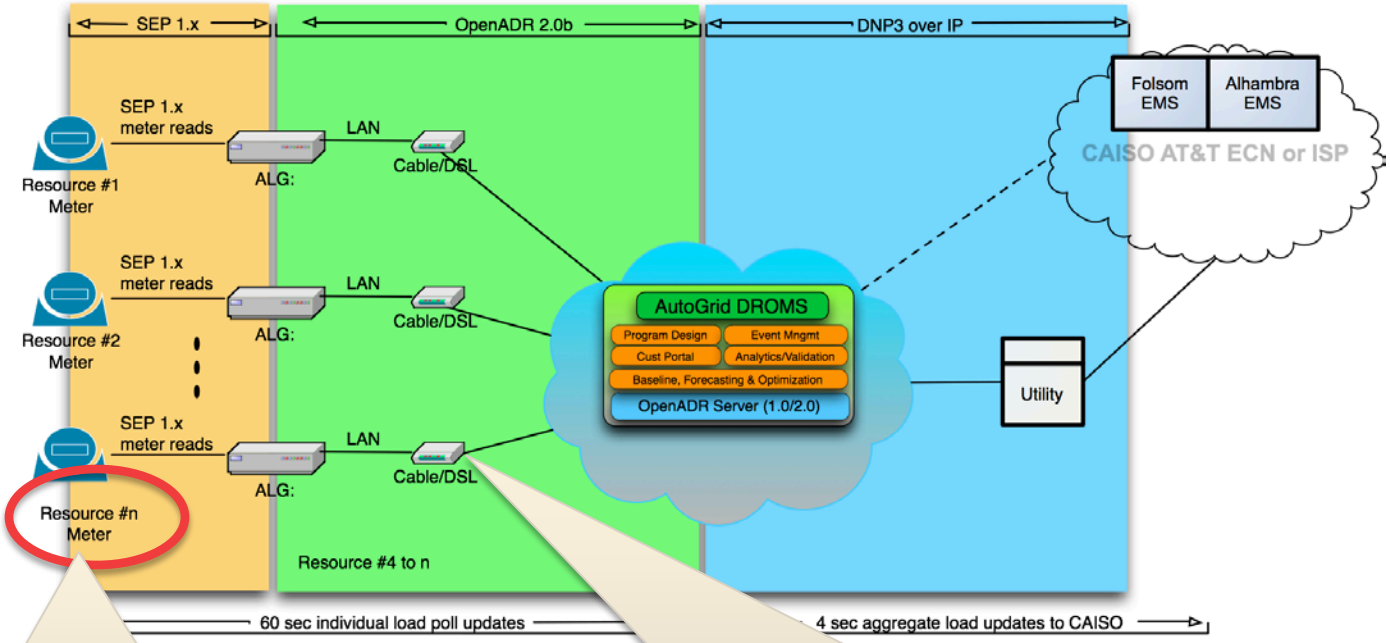


Data from 980 M Smart Meters			
Intervals	15 min	1 min	1 sec
Annual Data	3,100 TB	148,500 TB	**431,000 PB***

*6 Petabytes = the entire US Library of Congress x 50

Graph Sources: Zpryme, Brattle, US EIA

Example: CAISO Proxy Demand Response applied to Residential Aggregation



Certainly >100k easily scaling to >1M

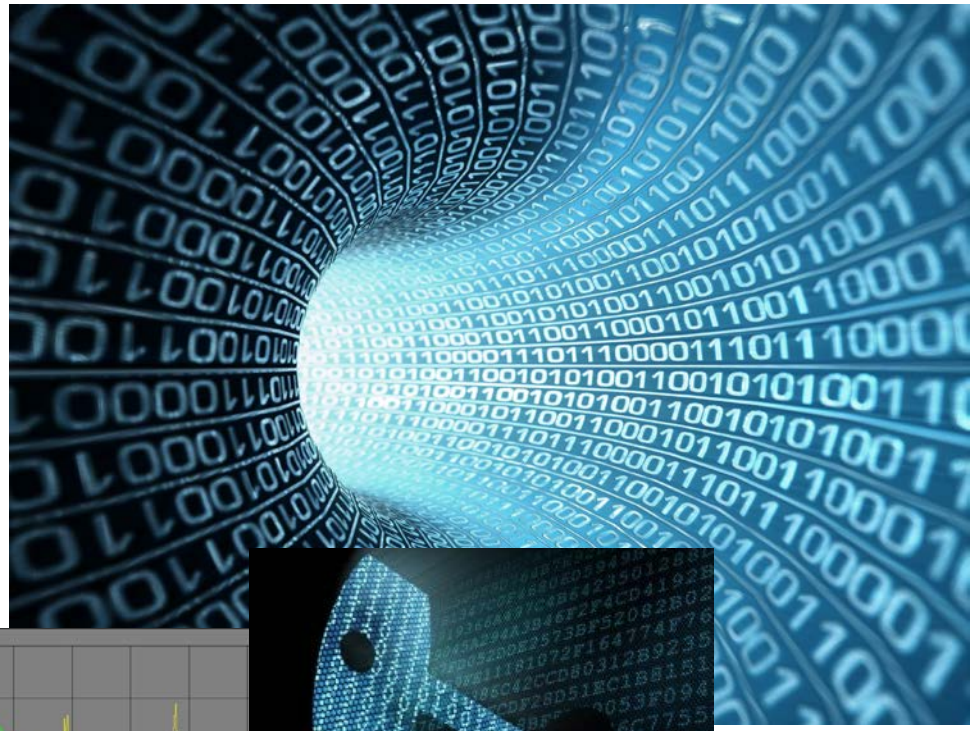
@ 1 min which is min for PDR this is >10TB/yr for 100k and 10PB/yr for 1M

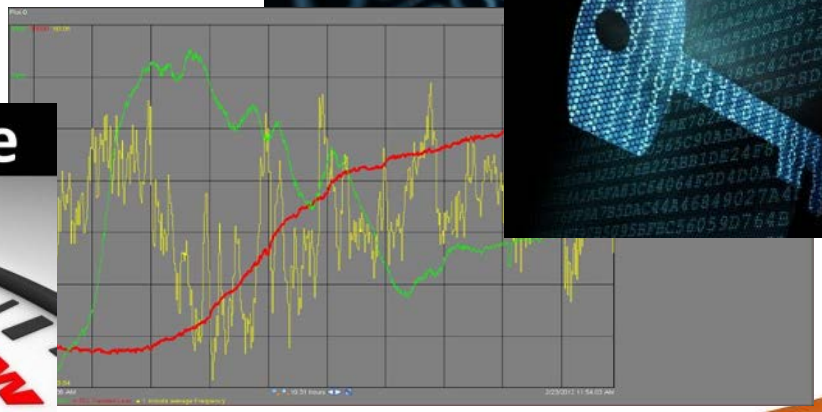
- Easy for Cloud and NoSQL, very challenging if not prohibitive for traditional local dbase models

…and these systems need Build, Dev, Test, Run and Disaster Recovery… so multiply by 5

The Concept is Simple…

- Extract relevant data from existing disparate sets
- Predict outcomes and optimize solution
- Execute in real-time to improve operational decision-making





The Reality is Much More Complex…

Every source of data is different

Cada fuente de información es diferente

每一個數據源是不同的

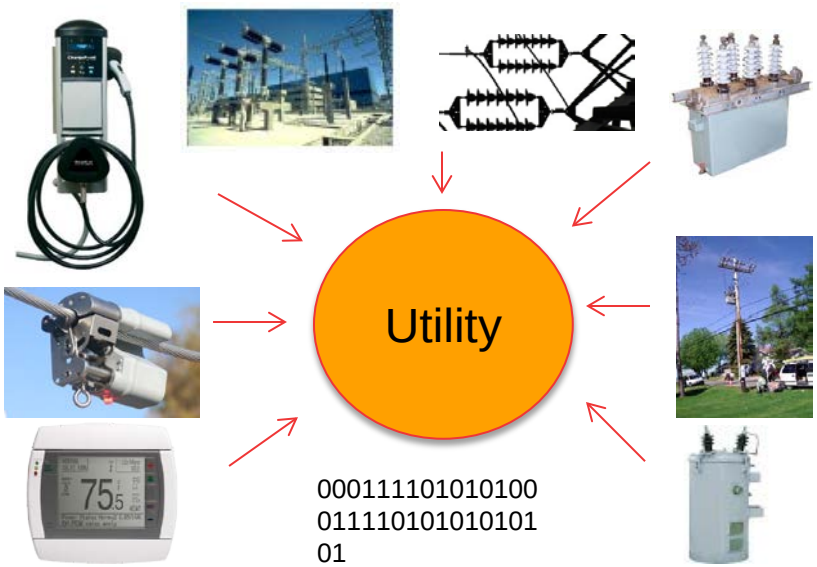
Ogni fonte di informazione e diverso

データのすべてのソースが異なっている

Jede Quelle von Daten verschieden ist

แหล่งที่มาของข้อมูลทุกที่แตกต่างกัน

Chaque source d'information est différent



Utility-scale solutions must be:

- **Safe & Reliable:** across all variations and unknowns
- **Scalable:** to millions of end points and Diverse loads (residential to industrial)
- **Forward & Backward Compatible:** support migration from to legacy systems to open, standards-based solutions
- **FERC Compliant:** Solve for complex rules around aggregate load shed (ie. > 300MW)
- **Complete solution:** not just a communication server

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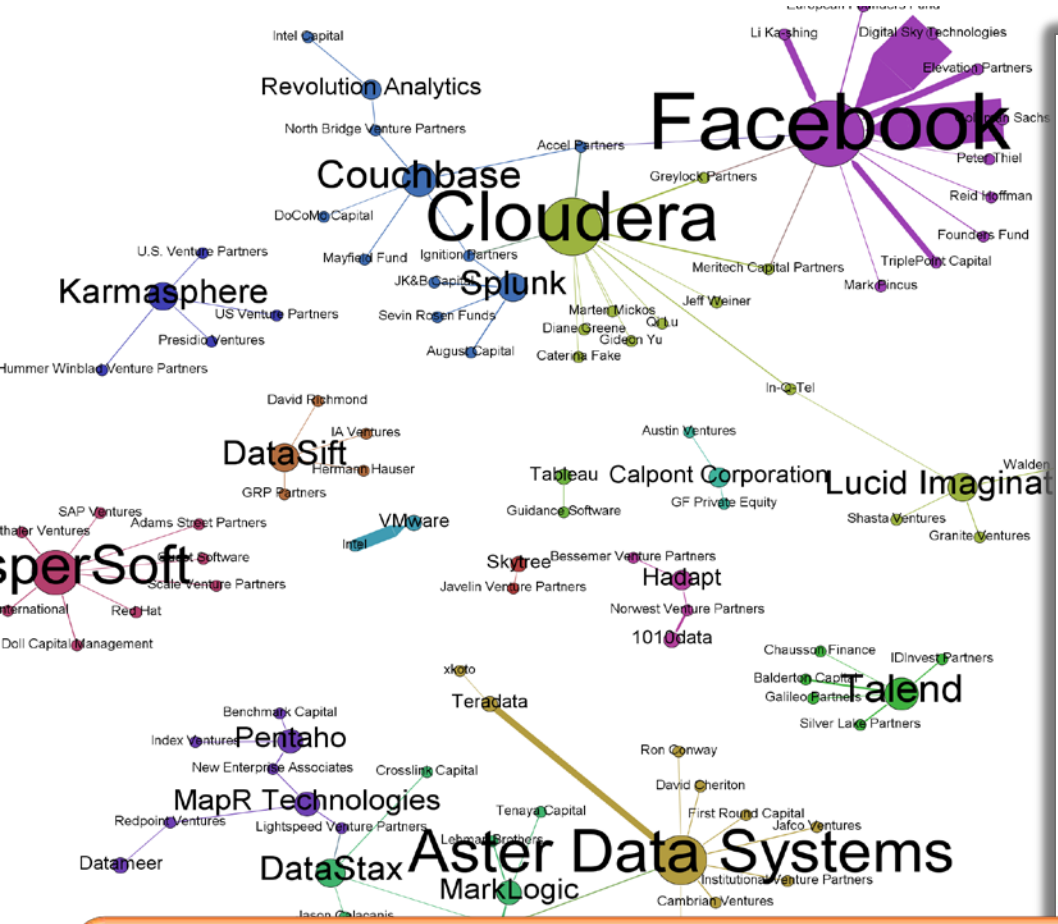
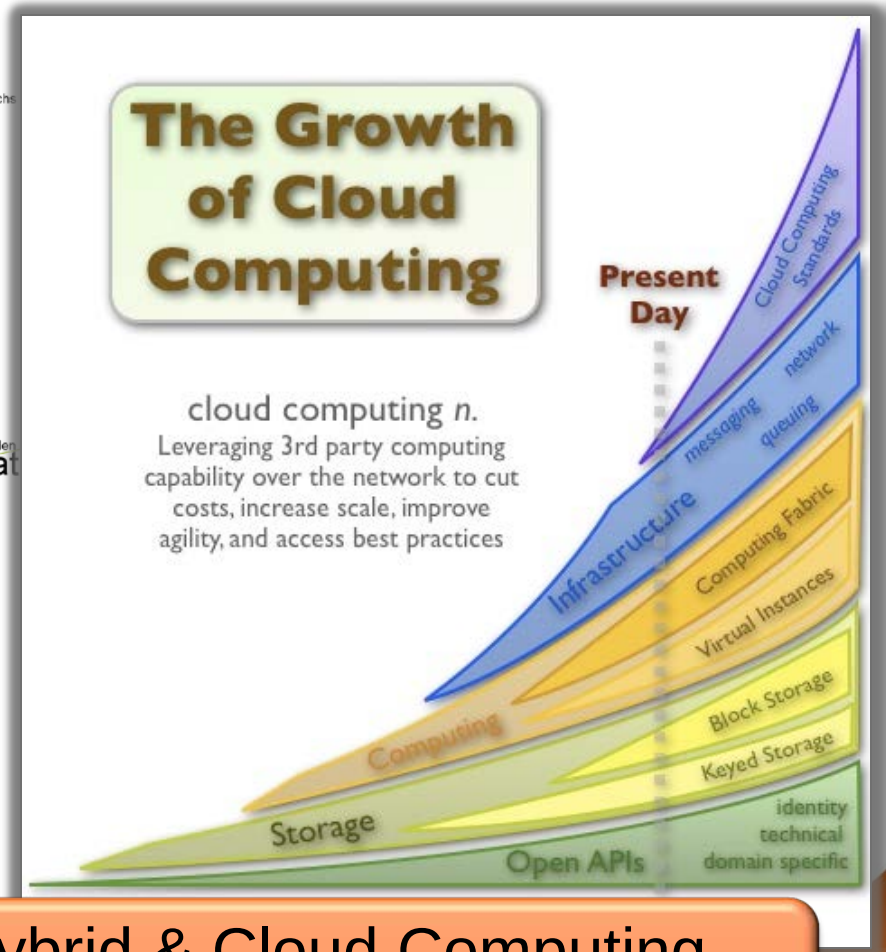
And Change is Hard…

- Utilities/ISO/RTO/BA are bound by their legacy
  - Safety and Reliability are the priorities
  - Current regulatory structure does not reward risk
  - Status Quo is “OK”, no upside for innovation
  - Decades of functioning technology solutions make change problematic
  - 100’s of critical applications in place
- Smaller Utilities need highly cost-effective solutions
- Many large, closed, vertically integrated systems

But, we are entering the 3rd Generation of Cloud, Big Data, and Analytics Companies





Technology Components for Hybrid & Cloud Computing, Data Science & Actionable Analytics are highly mature

At the highest level, we are(relative to the specific solution)…

Appling the last decade of Cloud and Data Analytics technology innovations to the Utility industry in a way that has never before been done

Building an **Energy Data Platform** to:

- Know what every resource is doing past, present, & future
- Scale reliably to millions of connections
- Process information in real-time
- Enable Rapid Deployment at extremely low cost
- Empower and Depend upon a Disaggregated technology model
- "No instructions Needed" complete, intuitive, easy to use

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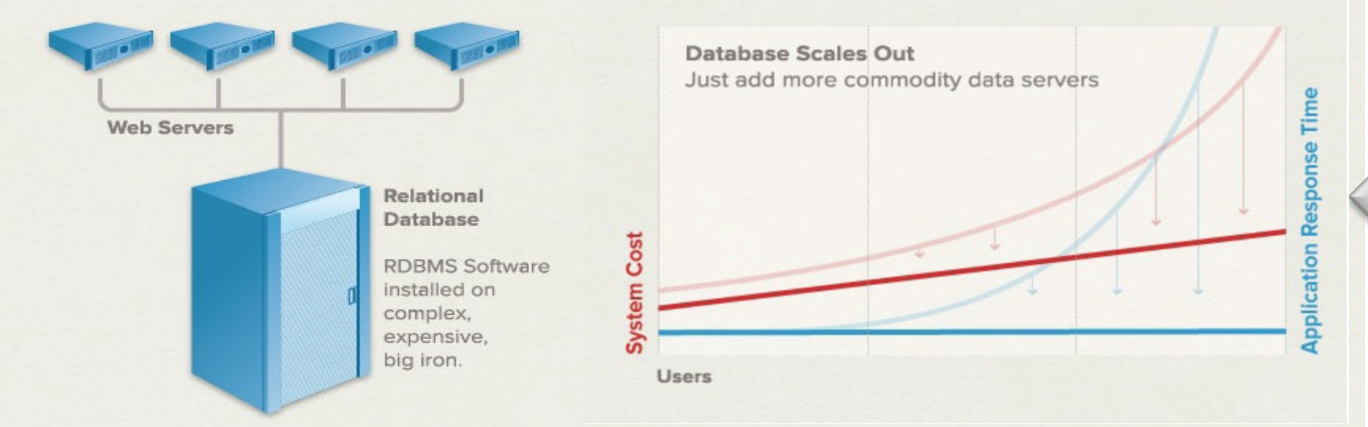
We took the approach of leverage leading technology, NoSQL architecture



Cost stays low, & response fast as databases scale

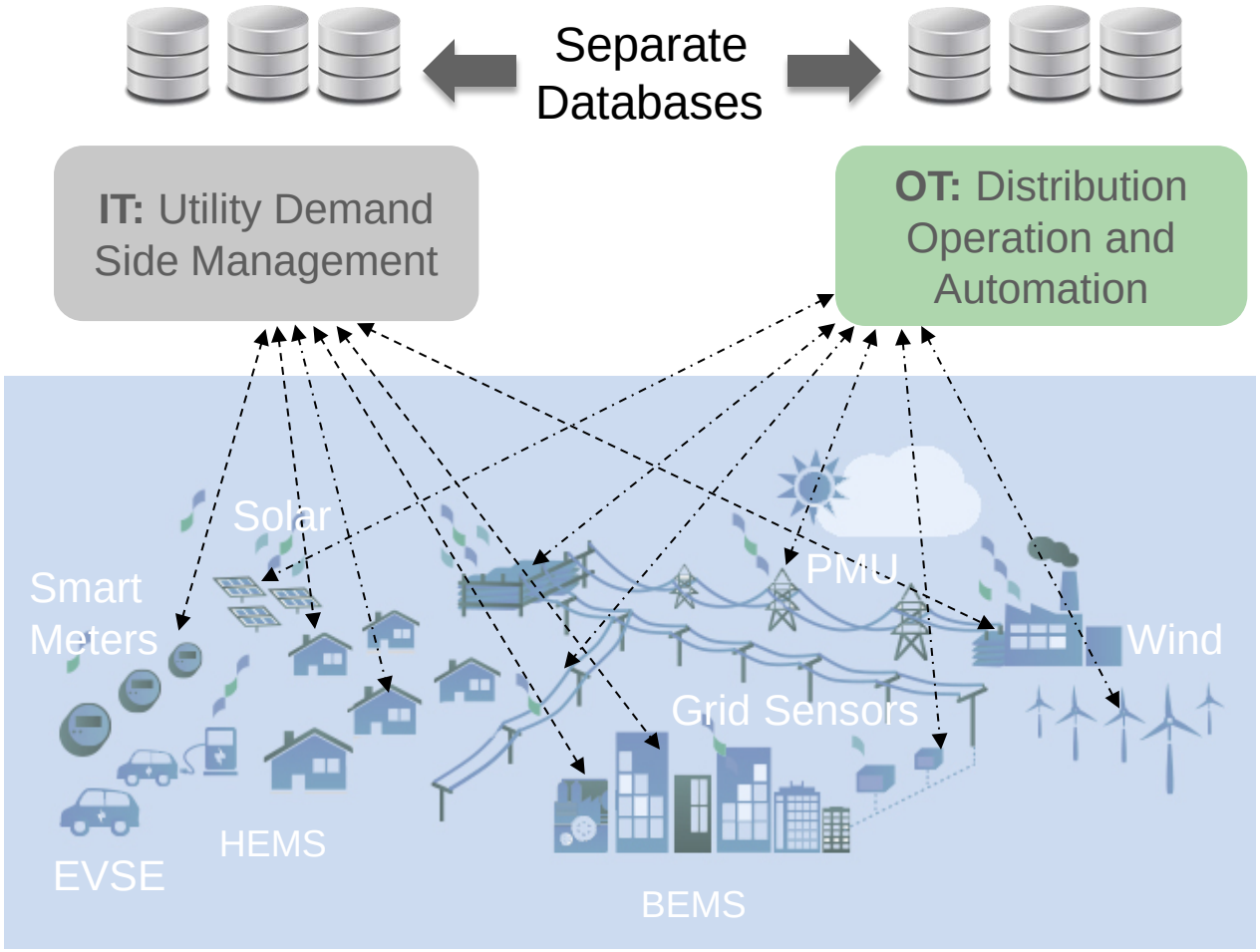
AutoGrid's Energy Data Platform (EDP)

Allows Real-Time Predictive Analytics on Big Data

100X-1000X time more scalable and cost effective than traditional methods

- ✓ NoSQL based Time-Series DB to manage petabytes of data
- ✓ Massively Parallel Computation using commodity servers
- ✓ Real time Stream Processing for predictive analytics

Create a tool the can solve the IT / OT Divide



DR ⟷ **VVO**

Integration creates **30% improvement** in "yield"

Challenges

- ✘ **No information sharing between IT / OT silos**
- ✘ **Inefficiencies in operation**
  - Reliability
  - Power Quality
  - Outage, Theft
- ✘ **High operating cost**
- ✘ **Vendor lock**

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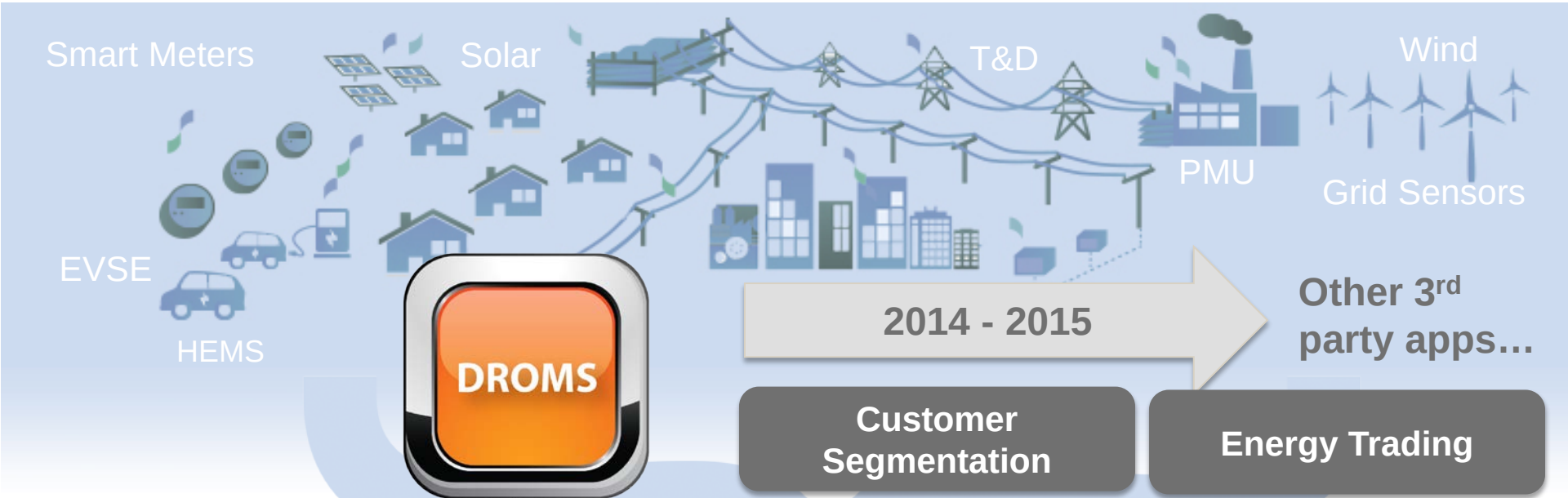
AutoGrid Enables IT / OT Convergence: *The Most Significant Business Process Transformation Happening Within The Grid*



Applications Layer

- Demand Response & Dynamic Pricing
- Renewable Integration
- Customer Segmentation
- Volt-Var Optimization
- Outage & Theft Analysis
- Energy Trading
- EV Management
- Energy Storage

Engines Layer

- Forecasting
- Optimization
- Notification
- Power Flow

EDP Layer

- Unique Data Model to Combine Big Data & Grid Physics for IT / OT Convergence

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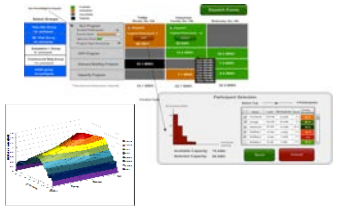
Demand Response Optimization and Management System (DROMS)™

Lowers Cost and Improves Yield of DR

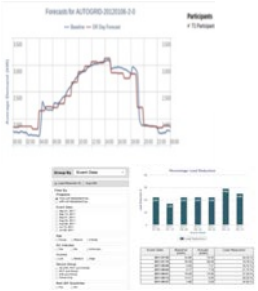
Accurate Individual Forecasts Aggregated Based on Your System Needs

Complete System of Record for all your Demand Management Activities

Optimize Demand Resources Across Programs, Resources and Geographies



Track Events, Provide Feedback to Customers, Create Settlement Data and fulfill Regulatory M&V Requirements



Fully-Featured Customer Engagement Platform for Communications via Voice Calls, Emails or SMS text

Largest Ecosystem of two-way communicating devices: SEP1.x/2.0, OpenADR1.0/2.0, Legacy, Proprietary,

openADR ALLIANCE ZigBee Alliance Energy

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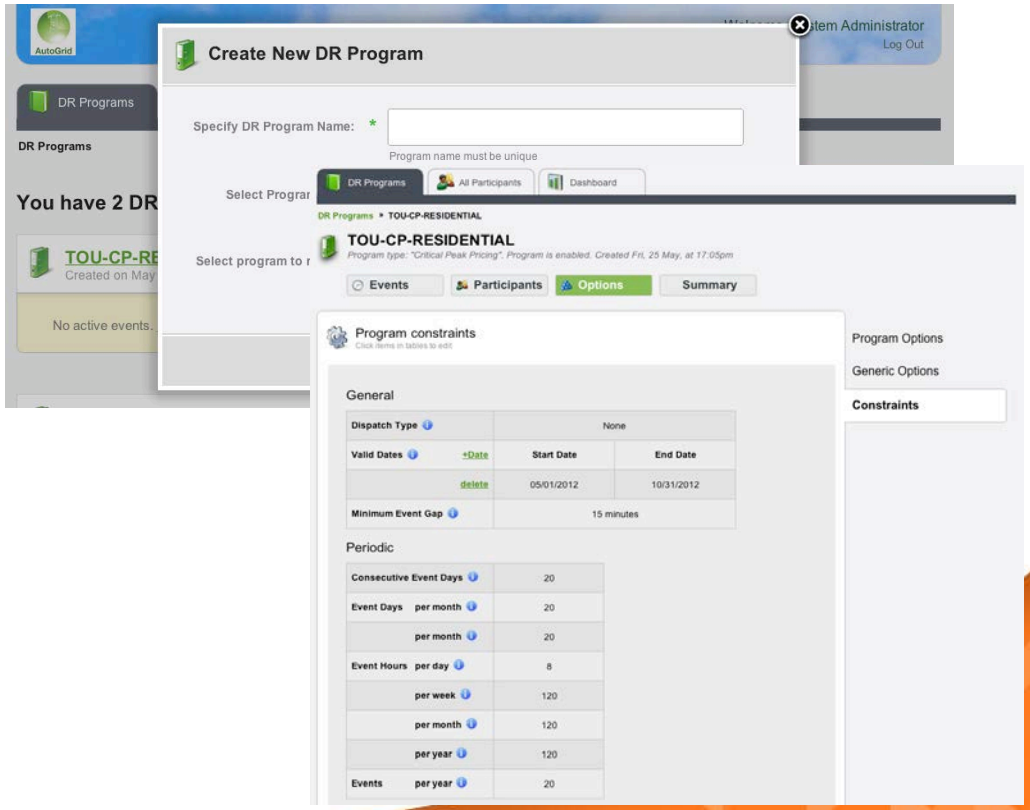
Enrollment and Program Management

A Complete System of Record for all your Demand Management Activities

Key Product Features:

- ✓ Easy-to-use interface
- ✓ Compatible with all known DR Programs
- ✓ Supports millions of customer participants
- ✓ Manage multiple programs and dual participation
- ✓ True operational visibility before, during and after events

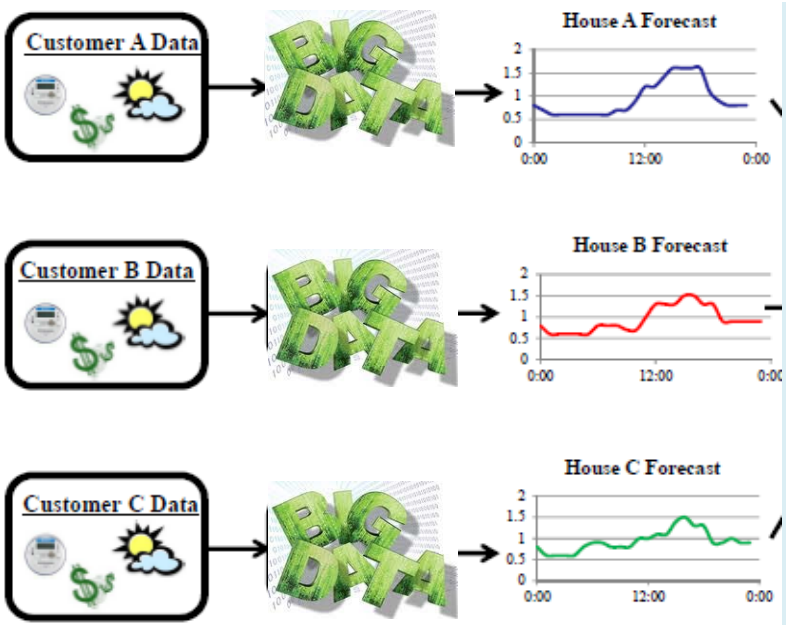


Real-time Resource Forecasting

Accurate Individual Forecasts Aggregated Based on Your System Needs

Key Product Features:

- ✓ Forecast individual loads and load shed potential
- ✓ Create highly-accurate, *individual* electricity models
- ✓ Machine learning techniques constantly improve models
- ✓ Static and dynamic aggregation of forecasts
- ✓ Run forecasts in real-time as grid conditions or other variables change
- ✓ Run millions of forecasts in parallel



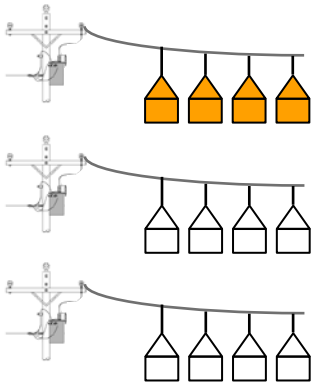
Real-time Resource Forecasting

Bottoms-up Approach Creates Granular Forecasting

Forecasting from the bottoms-up allows aggregation and deeper insight into customer groups:

By Demographic

By Geography



By Distribution Asset

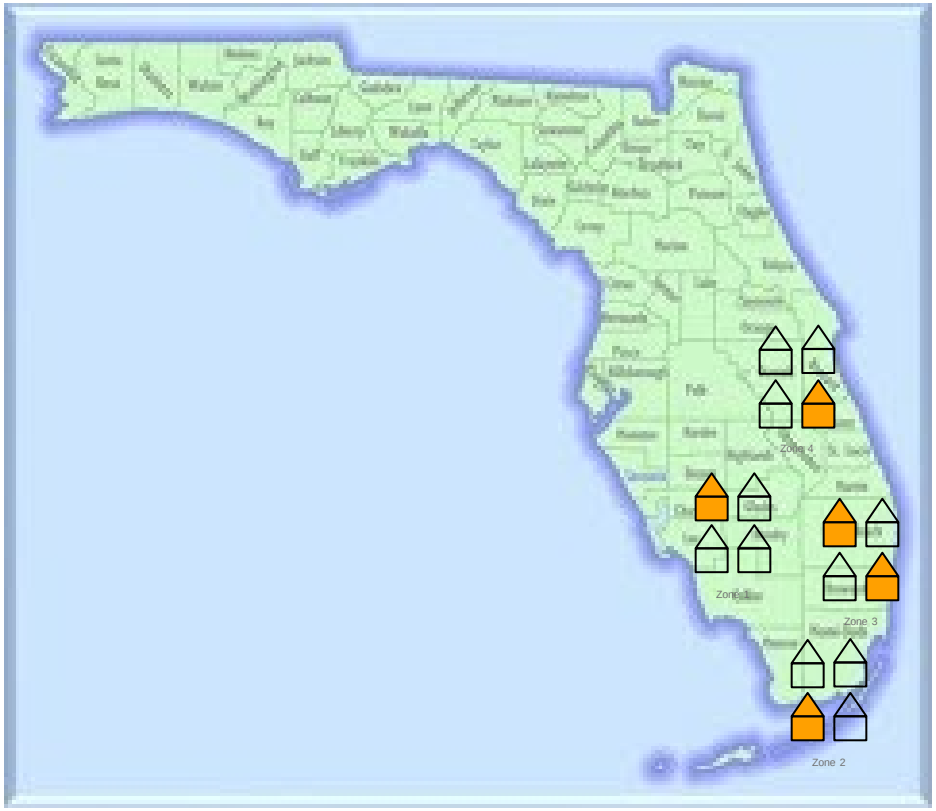
Key Benefits of bottoms-up approach:

- Better, more accurate representation of opt-outs; Load shed forecast is dropped by the forecasted load shed of the particular customer, rather than an average
- Allows forecasting of load shed under different price signals enabling optimization of a portfolio for hedging, revenue optimization, or reliability
- Best utilizes localized weather data leading to better regional forecasts
- Provide insights based on correlation of data points

Real-time Resource Forecasting

Bottoms-up Approach Provides Insightful Pivots

Meter-level data and forecasts can be aggregated into insightful, accurate pivots



Customers on direct load control program

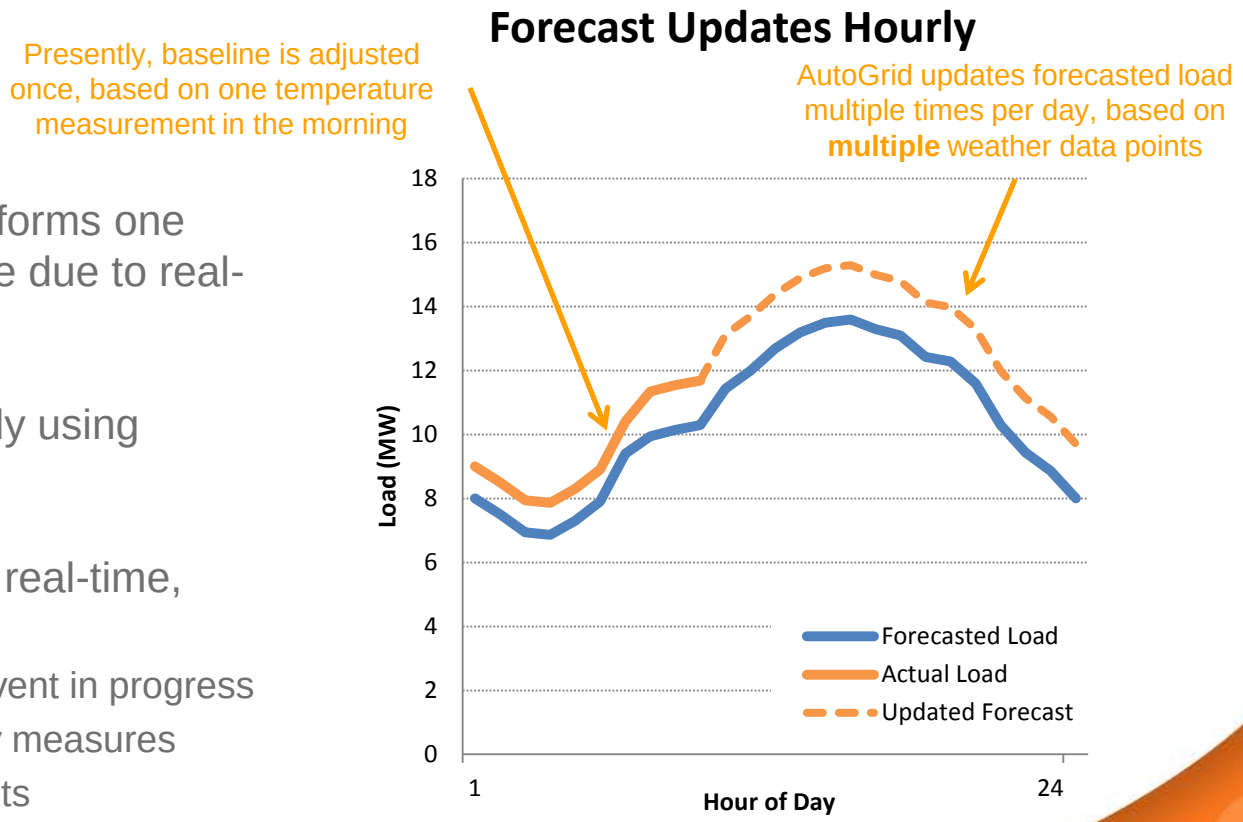
- **Example**: If all customers **on direct load control** AND **in zone 3** are called, what is the forecasted load and load drop in zone 3?
- In unique situations without previous data, the bottom-up forecast captures the behavior of different segments.
  - E.g., when July 4 falls on Sunday, commercial sector may look like a Sunday while residential sector may look like a typical July 4

Real-time Resource Forecasting

Architecture Enables Fast, Real-time Forecasting

AutoGrid's parallel database structure allows forecasts to be **bottoms-up**, **fast**, and **scalable** over a large customer base. By contrast, competitors with relational database systems can only deliver 2 out of these 3.

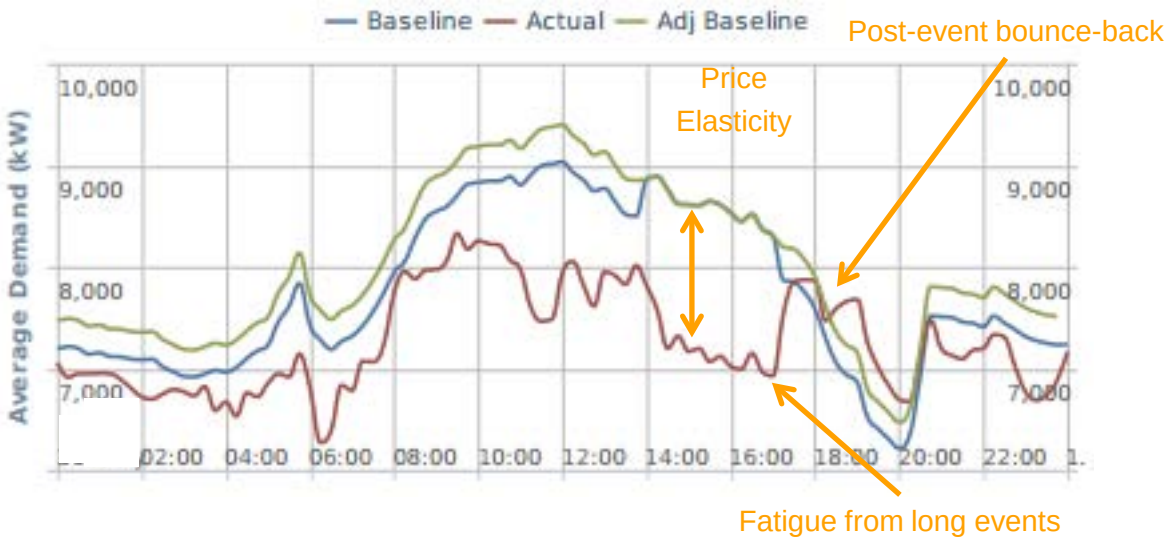
- Scalable infrastructure performs one million forecasts per minute due to real-time stream processing
- Model updates continuously using Hadoop framework
- Forecasts updated in near real-time, allowing decisions on:
  - How long to continue an event in progress
  - Whether to call emergency measures
  - Location of additional events



Real-time Resource Forecasting

Architecture Enables Fast, Real-time Forecasting

- Algorithms capture:
  - Price elasticity – load shed as a function of price
  - Post-event bounce-back patterns
  - Fatigue from long events or multiple back-to-back events



- Competitors' algorithms generally only use load shed history and temperature; they do not capture response to DR events

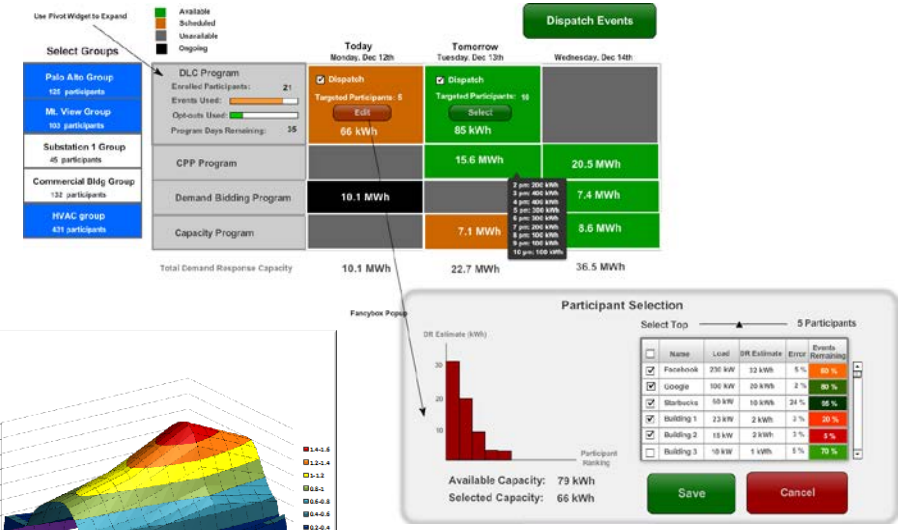
- AutoGrid uses best-of-breed algorithms from the areas of marketing science and machine learning
  - Bayesian models leverage patterns across multiple meters to accurately forecast shed response for a given meter under different in situations with few events
  - Support vector regression for forecasting baseline load levels of meters with highly volatile and irregular load patterns

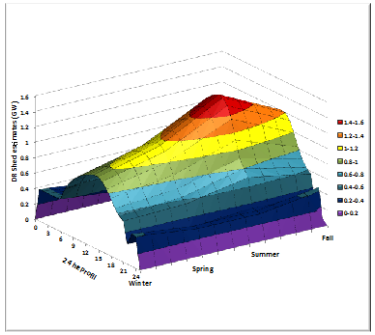
Real-time Resource Optimization

Optimize Demand Resources Across Programs, Resources and Geographies Through Control and Situational Awareness

Key Product Features:

- ✓ Unified view of all of your programs
- ✓ Visualize program constraints and how they interact to avoid double counting resources
- ✓ Transition DR from finite discrete events /year to a real-time resource
- ✓ Optimizes monetization of demand flexibility across programs – capacity, energy, reserves, regulation





Real-time Resource Optimization

DROMS Optimizes for Several Objectives

DROMS scheduling optimizes for the desired objective, when the number of programs, constraints, and decision variables grows too complex for human intuition.

DROMS Optimizer schedules events in future days

M	Tu	W	Th	F
x	x	?	?	?
x		?	?	?
	x	?	?	?

Inputs:

- Weather forecasts
- Power plants in service
- Program constraints

DROMS Scheduling Optimizer

Second-order effects:

- Fatigue
- Bounce-back

Minimize Energy Procurement Costs

M	Tu	W	Th	F
x	x	x		x
x		x		
	x		x	

Minimize System Peaks

M	Tu	W	Th	F
x	x	x		x
x			x	
	x		x	

Maximize MW called

M	Tu	W	Th	F
x	x	x		x
x		x	x	x
	x		x	x

Optimization outputs include:

- Days to call events
- Which program(s) to call
- Which zone(s) to call
- Price (for VPP programs)

Customer Notification Engine

Fully-Featured Customer Communications Platform for Voice Calls, Emails or SMS text

Key Product Features:

- ✓ Communicate via voice calls, emails or SMS text
- ✓ Highly scalable– support millions of participants
- ✓ Multi-language support – communicate in any language
- ✓ Allow customers to opt-out
- ✓ Advanced analytics and reporting to track customer receipts

- Local telephone numbers
- Message status, receipt, hangups, callbacks and logs
- Record calls for future evaluation

- Delivery optimization
- Feedback loop
- Email status: delivered, bounces, repeat bounces, spam, open tracking, click tracking, and more

- Delivery optimization
- Message status
- Feedback loop

Automated Demand Response

The largest ecosystem of direct, two-way, machine to machine communications to C&I and residential devices, including EVSEs

Key Product Features:

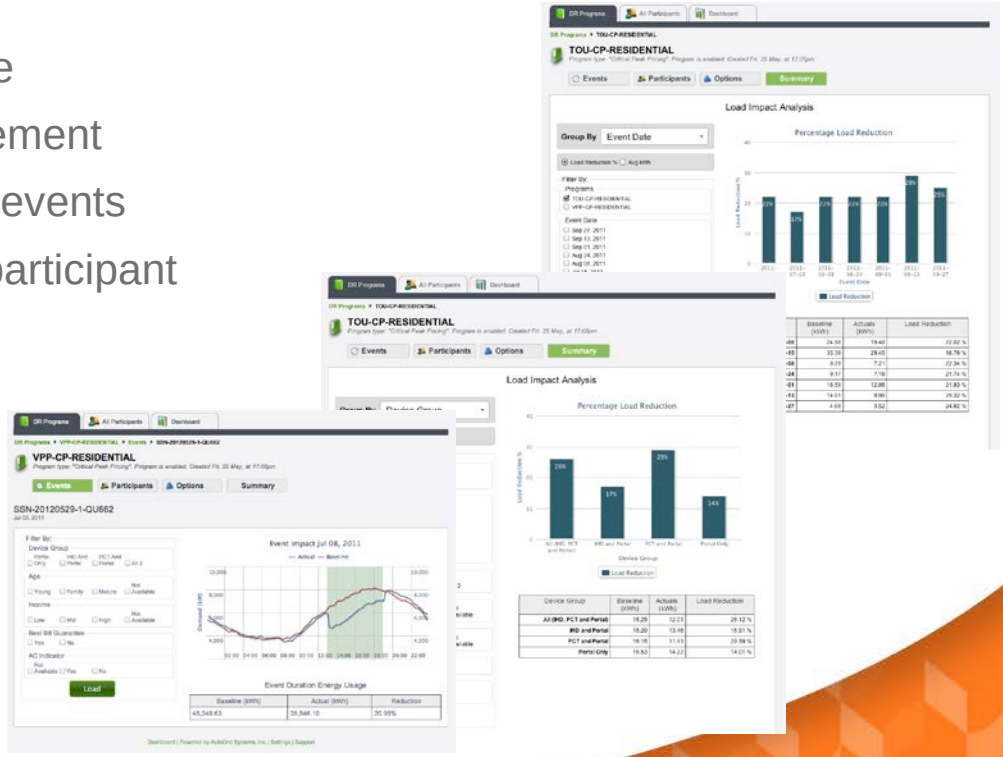
- ✓ Central point of control to manage customer devices over multiple head-ends
- ✓ Compliant with OpenADR 1.0 and 2.0
- ✓ Compliant with Smart Energy Profile 1.x and 2.0
- ✓ Seamless integration with AMI Networks from Itron and Silver Spring Networks
- ✓ Interoperable with dozens of hardware platforms across C&I and residential
- ✓ Can integrate with any proprietary platform

Post-Event Analytics

Robust Real-time Analytics to Track Events, Provide Feedback to Customers, Create Settlement Data and Fulfill Regulatory M&V Requirements

Key Product Features:

- ✓ Run post-event analytics in real-time
- ✓ Create billing determinants for settlement
- ✓ Run M&V reports immediately after events
- ✓ Determine load shed potentials by participant class
- ✓ Audit legacy programs to identify non-performing devices



Demand Response Optimization and Management System (DROMS)™

Lowers Cost and Improves Yield of DR

Best Technology

1. **Rapid, Low Cost Deployment**
   90% lower price point than traditional DR
2. **Higher Reliability & Yield** 30% more effective than other DR solutions; dispatchable
3. **Open Ecosystem**
   100% hardware neutral
4. **Massively Scalable**
   Millions of endpoints, petabytes of data
5. **Higher End-Customer Satisfaction** More customer choice & flexibility on program types, hardware, communication methods

Available NOW

- ✓ Proven at scale in production
- ✓ More customer deployments than any other DRMS vendor
- ✓ Processing 3X more data than all other DR vendors combined!
- ✓ Most extensive device support in the industry from 100+ vendors
- ✓ Only DRMS vendor to have met all Security Standards of Large Utilities on the Cloud

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Closing Thoughts

- Technology is not a major barrier preventing more efficient use of energy resources
- Lack of consistent policy (or maybe better stated, market mechanisms) is a barrier to private sector investment
  - Complexity of integrating across over many ISO/RTO/BA markets and State Utility Commissions
  - Lack of ability for private sector to monetize investments and have relative confidence in ROI if technical goal is achieved
  - ie, lack of consistency in: Direct Access, Dynamic Energy rates, Elasticity from Wholesale to Retail Markets, Transparent Delivery cost mechanisms….

We as an industry should start rationalizing this this premise and work to pose solutions