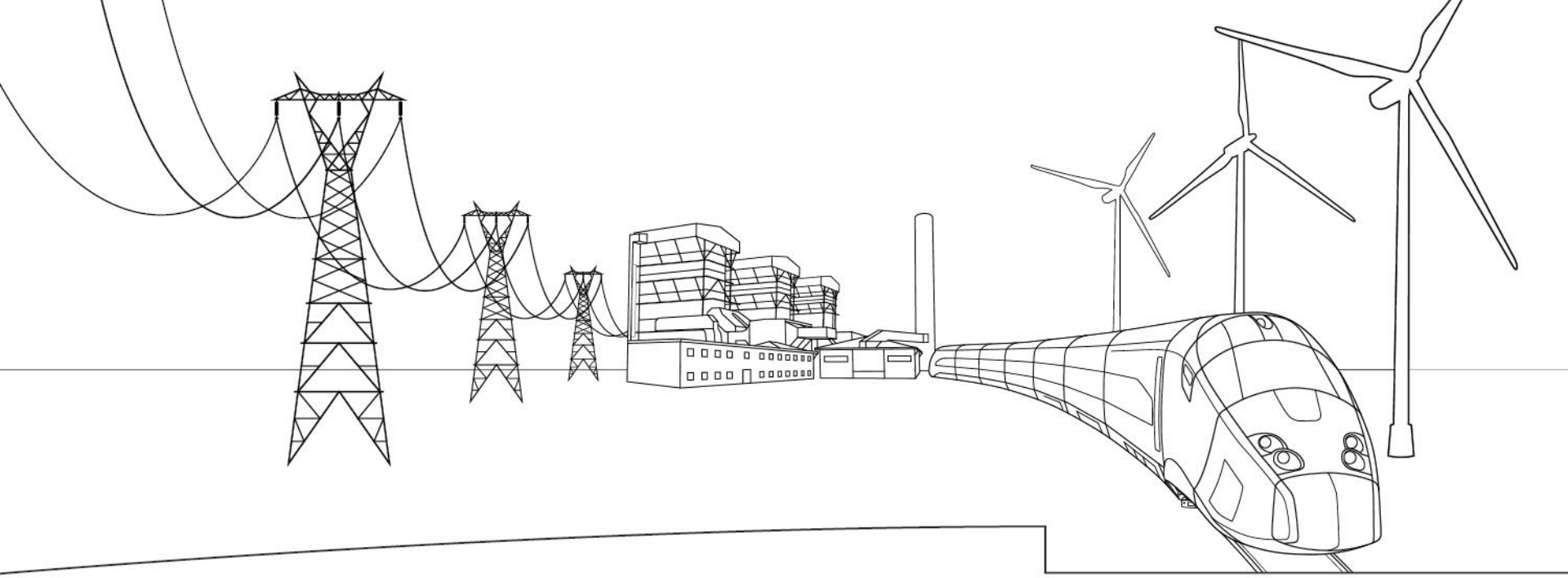
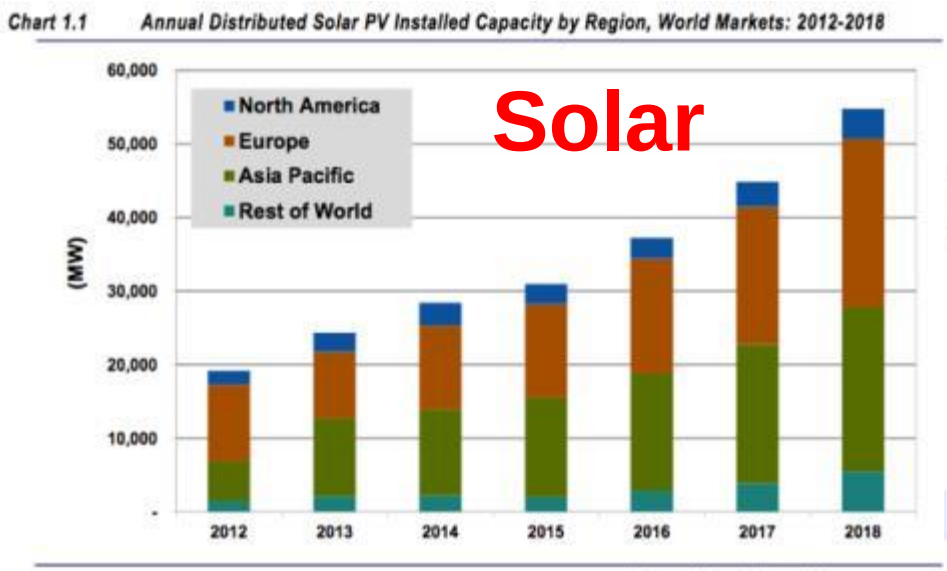


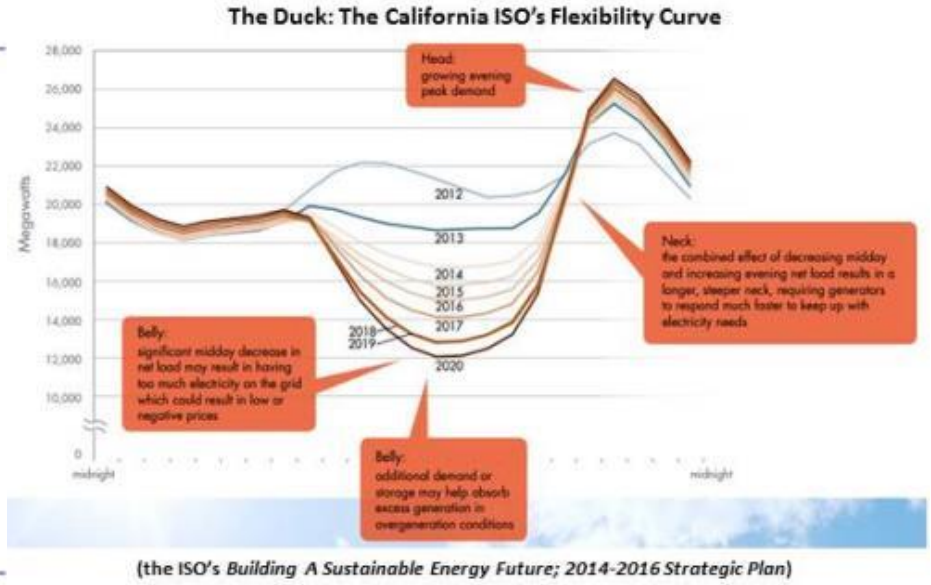
DER – A Driver for Utility Transformation

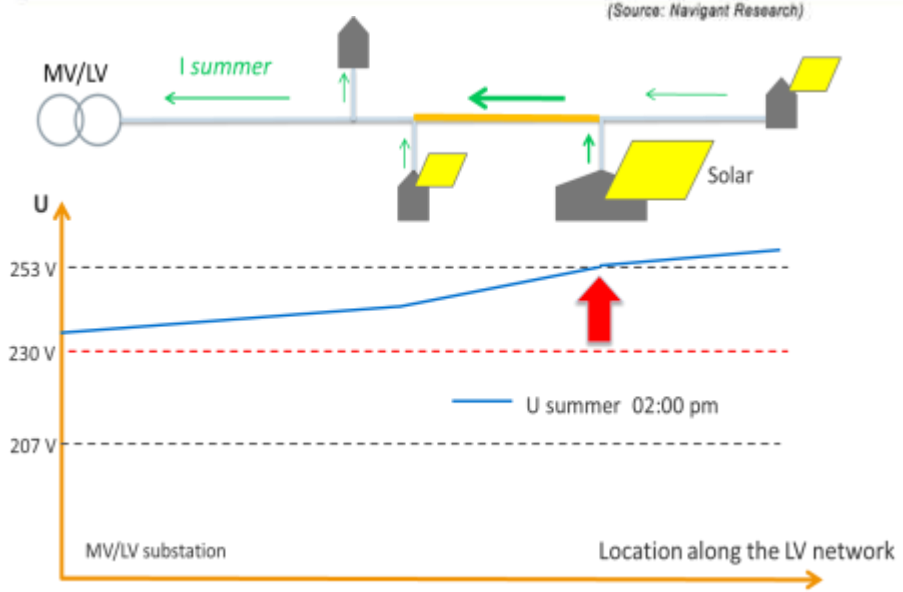
Dr. David Sun, Fellow IEEE
david.sun@alstom.com
February 1, 2015

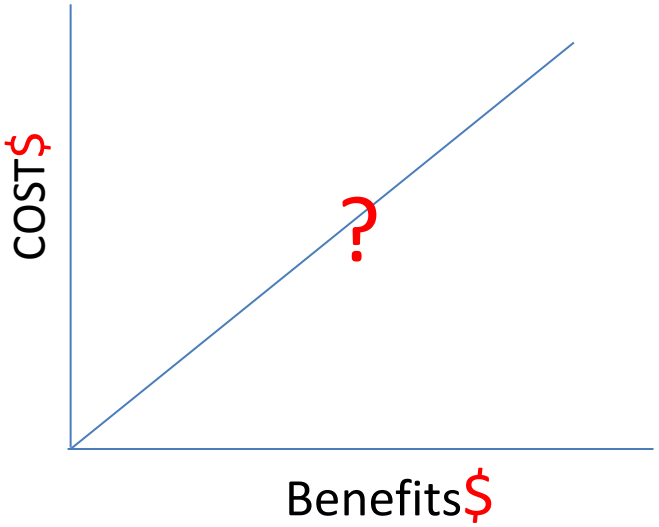
ALSTOM
Shaping the future

Distributed Energy Resources









Industry Transformation

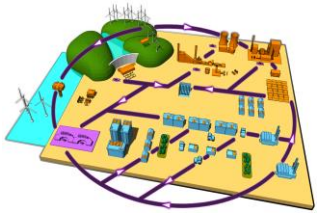
Classic Utility

- Vertically integrated
- Cost-based operation
- Physical infrastructure

Competition

- Open transmission access
- Genco divestiture
- Wholesale electric market

Smart-Grid

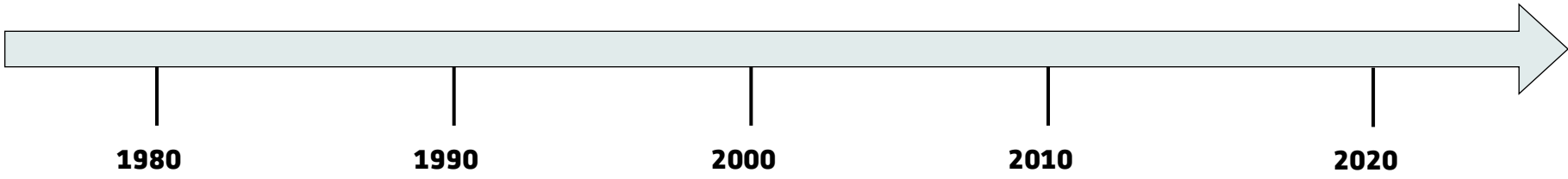


- Distributed intelligence
- Service valuation
- Prosumer choices

.

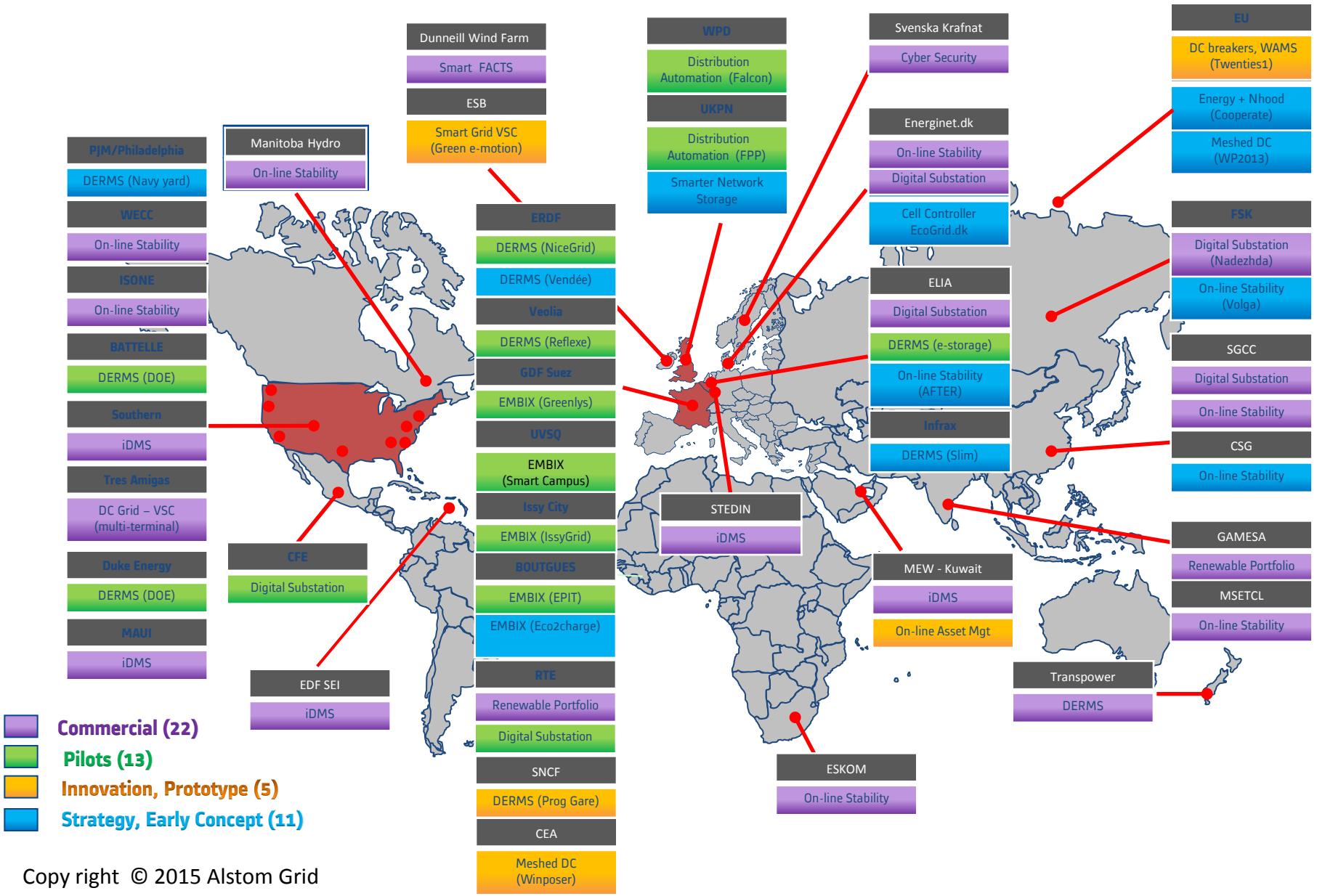
Smart City

- Sustainability
- Resiliency
- Connectivity



Evolving Energy Ecosystem

Alstom Smart Grid Program



Pacific Northwest Demonstration Project

What:

- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

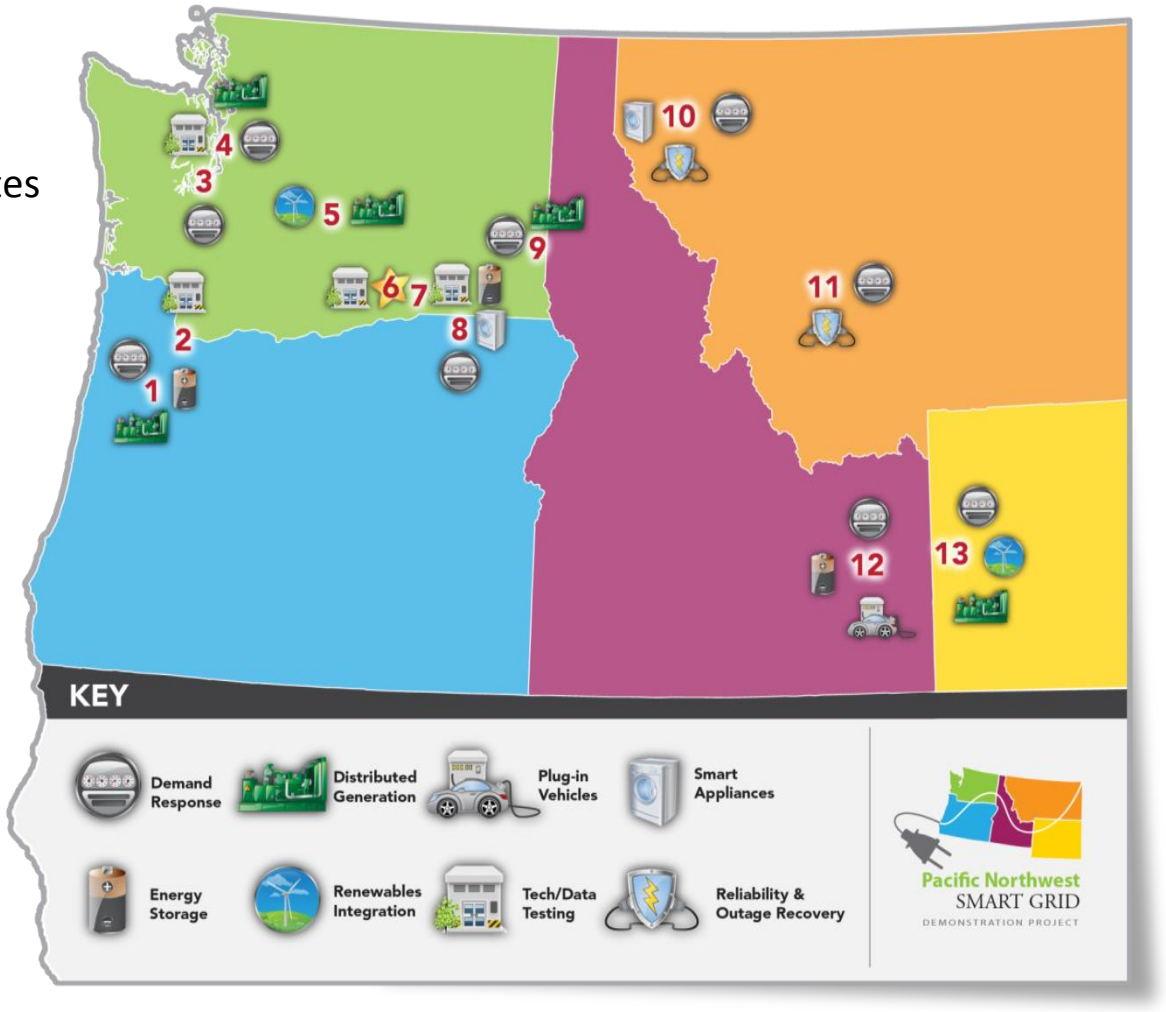
Why:

- Quantify costs and benefits
- Develop communications protocol
- Develop standards
- Facilitate integration of wind and other renewables

Who:

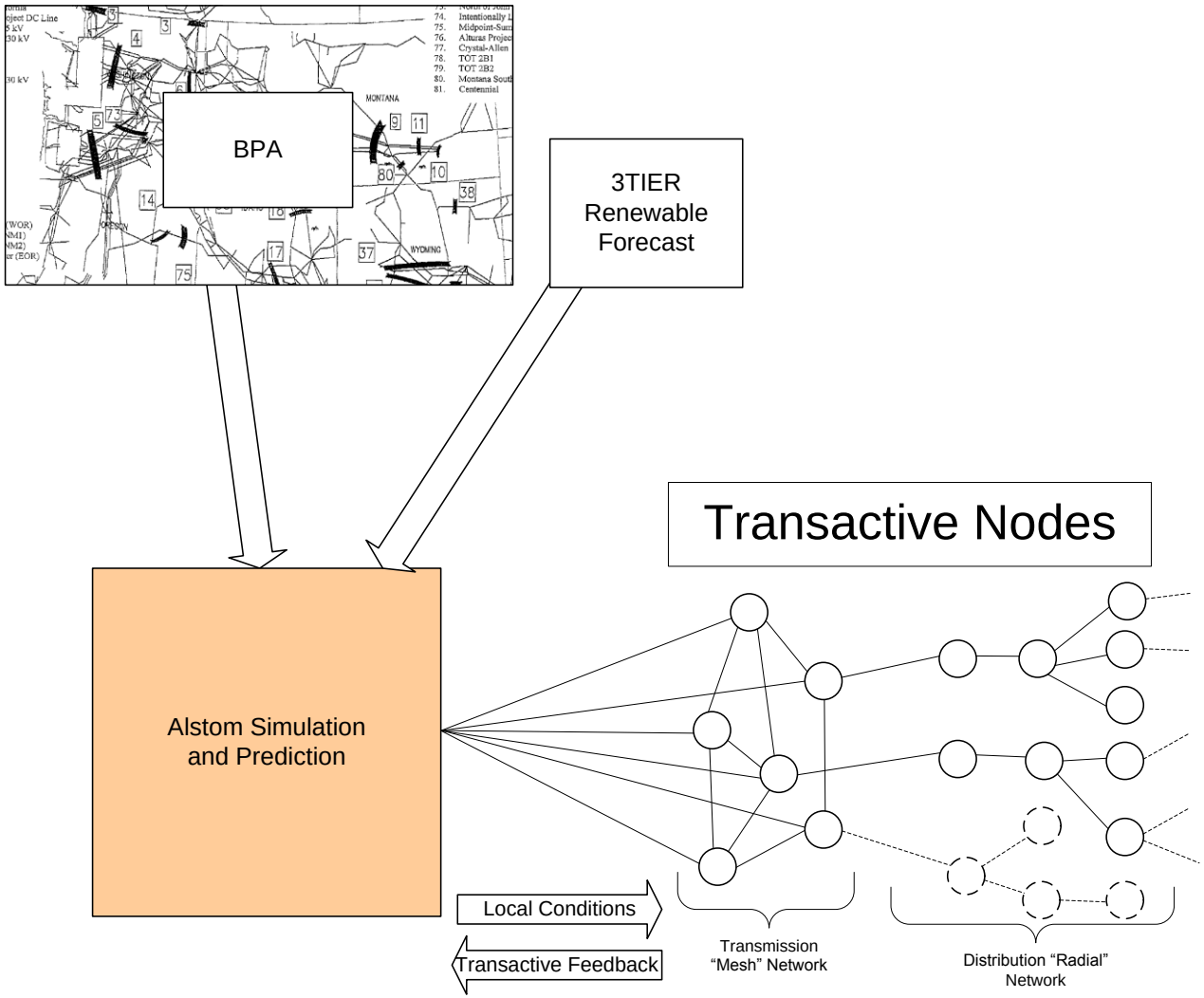
PNNL (lead), Alstom, IBM, ..

BPA, plus 11 utilities,
UoW, WASU



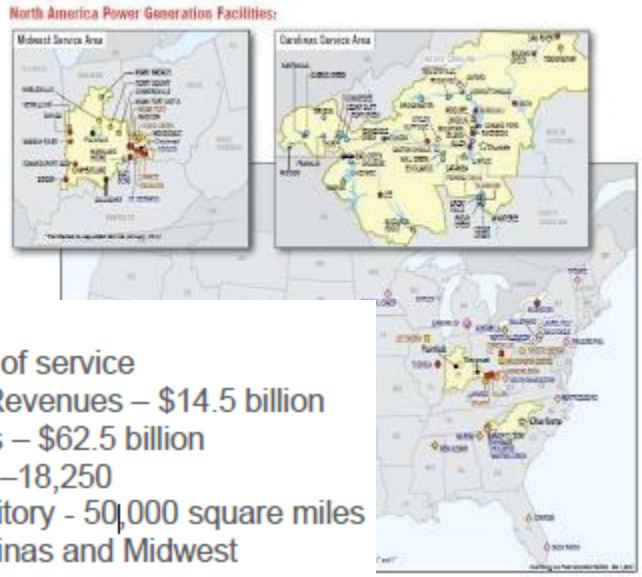
Northwest Regional Scheduling

Transmission Grid/Market Analytics



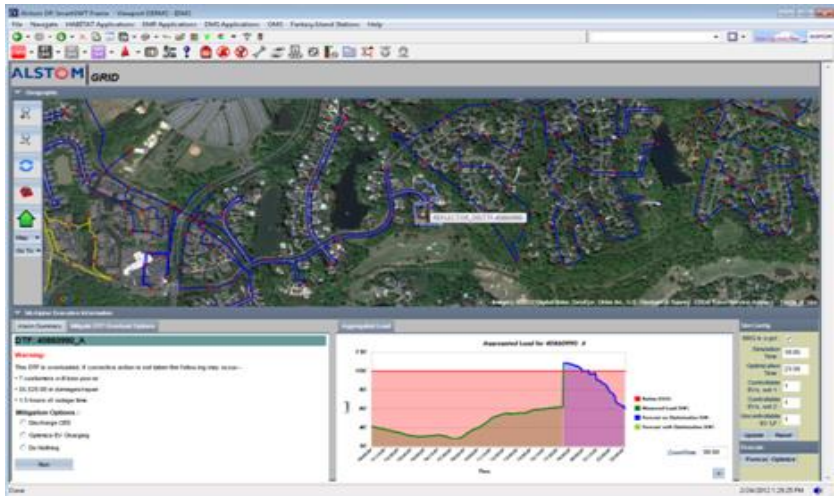
Duke Energy: Integrated Smart Distribution

DoE Funded DER Demonstration Project



At a Glance

- 150+ years of service
- Operating Revenues – $14.5 billion
- Total Assets – $62.5 billion
- Employees –18,250
- Service territory - 50,000 square miles in the Carolinas and Midwest



Six Priority Topics:: (Project Scope)

- Management and forecasting of DER (DG, storage, DR)
- Integration of network, market, and renewable resource models for next generation DMS.
- Advanced distribution modeling capability to accurately simulate/model smart grid operations.
- Accurate representation of the distribution system in real- or near real-time (capture real-time topology).
- Interoperability with and seamless communication between other management systems and data bases used by the utility
- Simulation of distribution systems based on real-time operational planning to analyze the benefits of smart grid assets.

Innovation R&D: Project Highlights

- Distributed intelligence: ES charging, PV swing management with intelligent devices and communication nodes
- DER-enabled Cold-load Pick-Up
- PMU-enabled advanced falut identification and isolation
- Micro-grid management: islanding, protection, control.

Advanced Operational Demonstration

- Pilot demonstration at McAlpine
- DMS Integration: modeling, database maintenance, DNAF+
- Operator friendly (UI, leverage field intelligence)

Envision Energy: Field Asset Deployment

DUKE ENERGY®

Substation

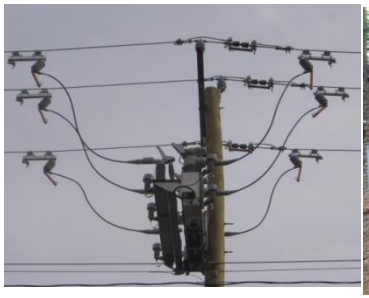
Sherrill's Ford (Marshall), Rankin, and McAlpine Substations

- **Solar PV**
- **Energy Storage**
- **DMS**
- **PMU**
- **Weather monitoring**
- **DERMS**

Distribution Circuit

6 McAlpine circuits

- **225 line sensors**
- **Solar PV**
- **Community Energy Storage**
- **~3,000 Comm. Nodes**
- **Intelligent Switches**
- **DERMS**

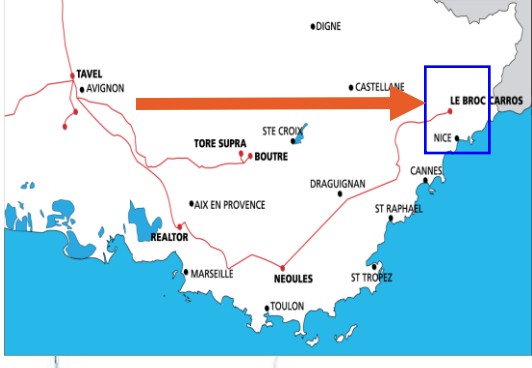


Customer Premise

~60 homes served by McAlpine circuits

- **Solar PV**
- **Home Energy Manager**
- **PEV**
- **Charging Stations**
- **Smart Appliances**
- **Demand Response**
- **In-home load monitoring**

NiceGrid Secondary Flexibility Markets



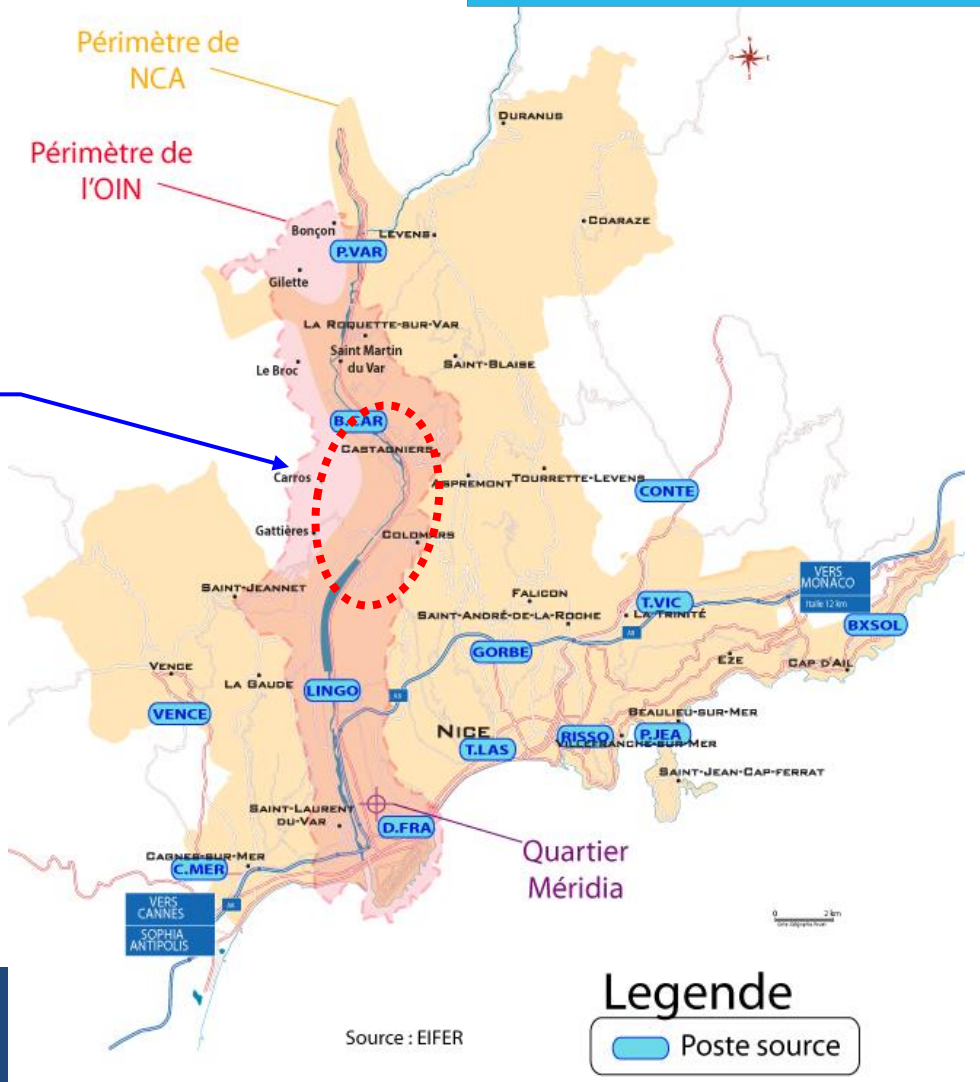
The demonstrator will be set up in the municipality of Carros (**South-East region of France)**.

- Increase of PV connections (MV and LV).
- Fragility of the electrical system in South East of France.
- Specific urban planning project with a "major national interest" legal status.

The demonstrator geographical area covers :

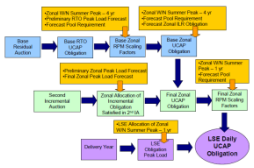
- the existing Carros industrial district
- the existing residential district "Carros le Neuf"

The geographical area is fed by several feeders linked to two primary substations. Three of them will be specifically used for the demonstration purposes (SEUIL6, FERRIER and TELEME). These three feeders can be meshed.

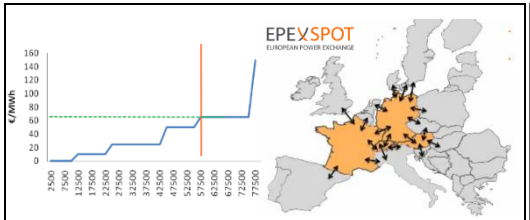


Nice Grid: DER/DSO/TSO Coordination

Whoesale Market Operator



Capacity Markets



SPOT Markets
Day Ahead or Intra-Day
(> 1MW)

Supplier
Trade Portfolio
Balancing

Réseau de transport d'électricité

Minute Reserve
Markets
(> 10 MW)

4)* Aggregation of DER capabilities

Aggregators

Distribution System Operator

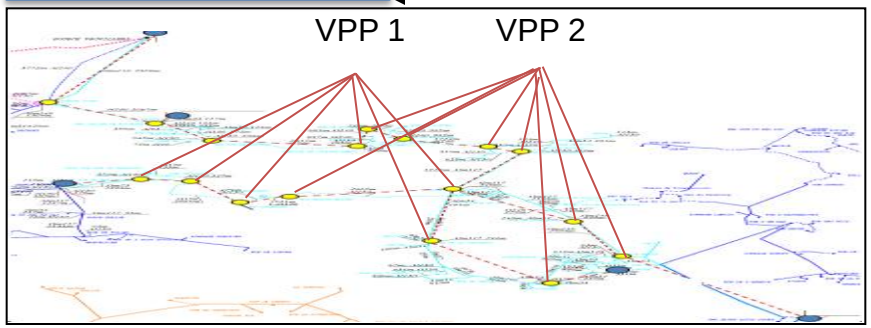
DERMS

DERMS
for Aggregators

1) Locational flexibility offered to DSO

2) DSO selects required reserves

3)* DSO validates use of remaining flex.



NEM (Alstom) DMS (3rd Party)

DER Registration

Market functions:
- Bidding
- SC Capacity Clearing
- SC Energy clearing
- Curtailment of Bid Capacity

Analytic functions:
- Forecasting (DER)
- Security Analysis (D-1 / D)
- Forward VVS
- Islanding
- Forecasting (PV, profiling)

Small SCADA

Analytic functions:
- State Estimation
- Security Analysis (planning, RT, expost)
- *Feeder Reconfiguration*
- Forecasting (LD)

Visualization | Reporting

Alarms/Events | Archiving

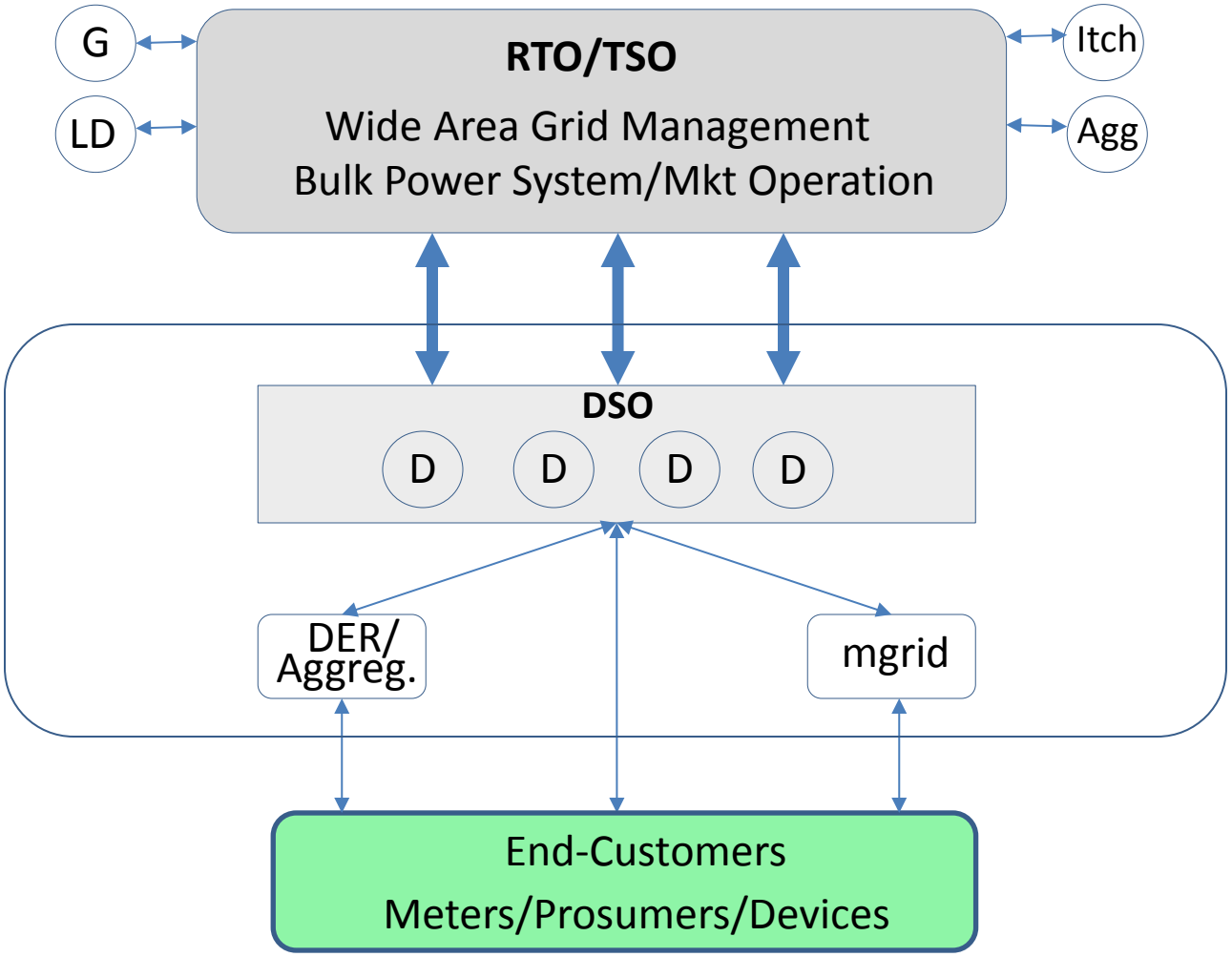
Grid State Model

SCADA | *AMR*

GIS & Grid Modeling & Planning

* Not part of Nice Grid demonstrator

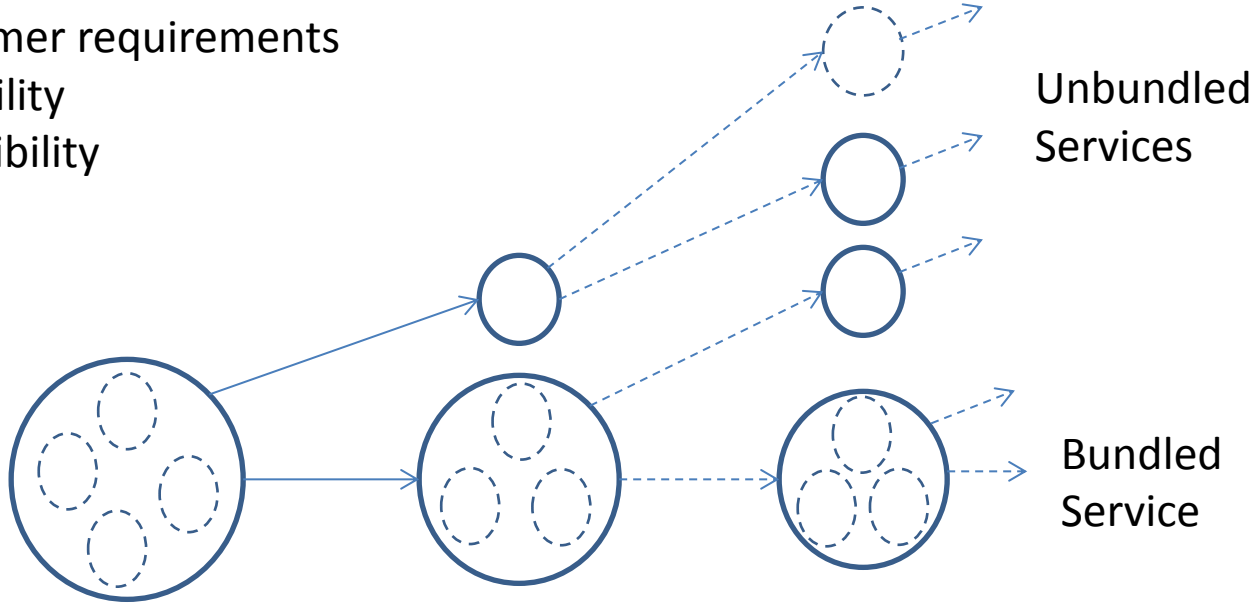
Hierarchical Distributed Business Model



Distribution Energy Services

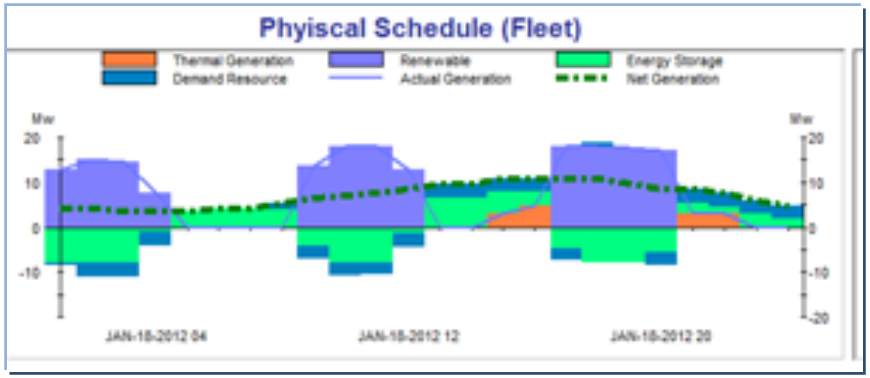
Services driven by:

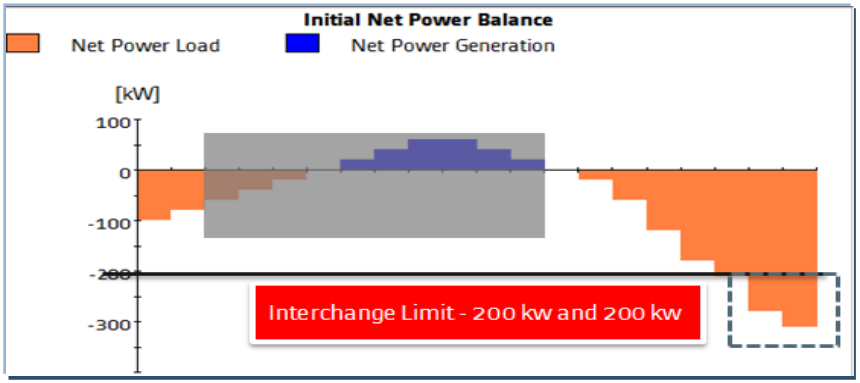
- Market/customer requirements
- Business viability
- Technical feasibility



DER Optimization Functions

- Energy Storage Scheduling
  - Price Arbitrage
  - SOC Level Management
  - Grid Congestion Management
- Substation DER Balancing
  - Grid Connected Operation
  - Island Operation
  - Misc Resource Scenarios
- Pre-Island Energy Adequacy
  - Energy Storage Optimization
  - Misc Islanding Scenarios





Als
to

Optimal Scheduling of DER Assets

Current Status of Optimization Applications

Summary

- Have gained acceptance; currently performing critical functions in Control Centers operations:
  - Bulk power grid (EMS): SE, OPF, UC,…
  - Wholesale market (MMS): Market Clearing (SCUC/ED, FTR)…
  - Distribution grid (DMS): VVC, Feeder Switching (AFR, FISR)…
- Have unrelenting demand for faster and smarter solutions
  - Problem definitions/characteristics
  - Solution technology: optimization + others

Current Status of Optimization Applications

Evolution of SCUC Optimization

Fixed priority order for unit startup and shutdown

Dynamic priority order (LR + DP)

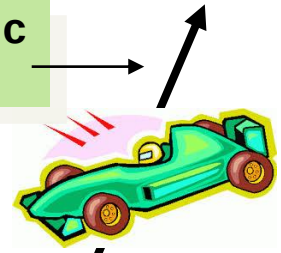
1996: Dynamic priority order sequential bidding (LR+ SB)

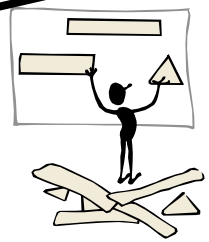
2001:Enhanced Lagrangian Relaxation

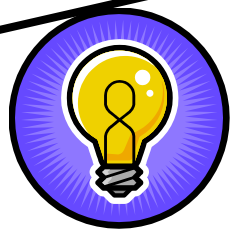
2003:Mixed-Integer Programming

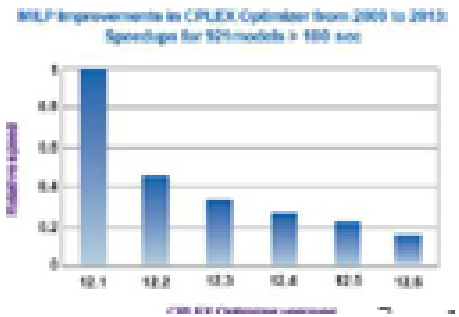
2013: AIMMS 3.13 & CPLEX 12.5

2016: Hybrid MIP with meta-heuristic and stochastic optimization



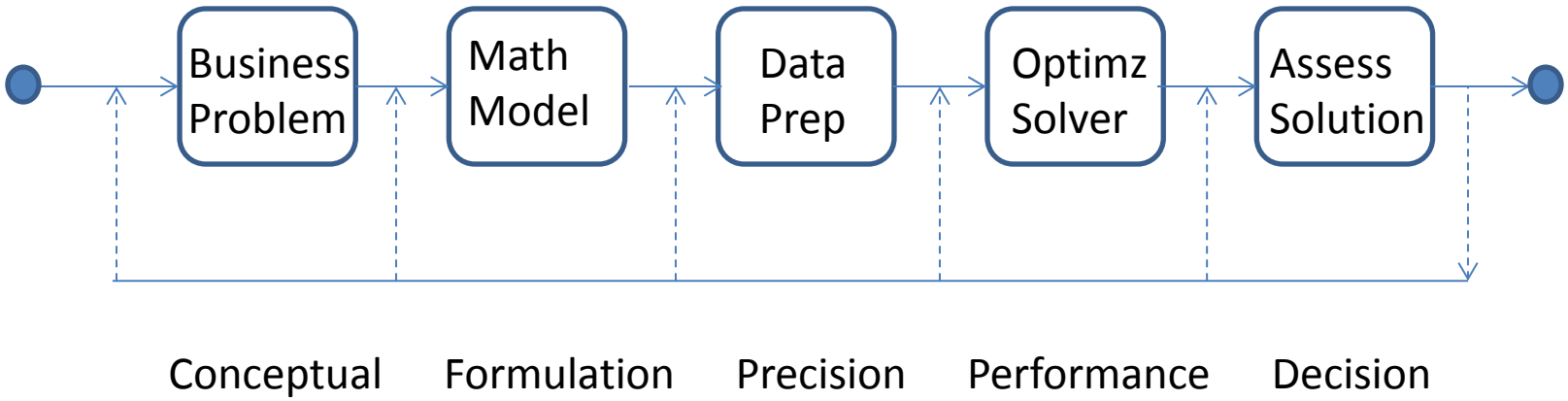






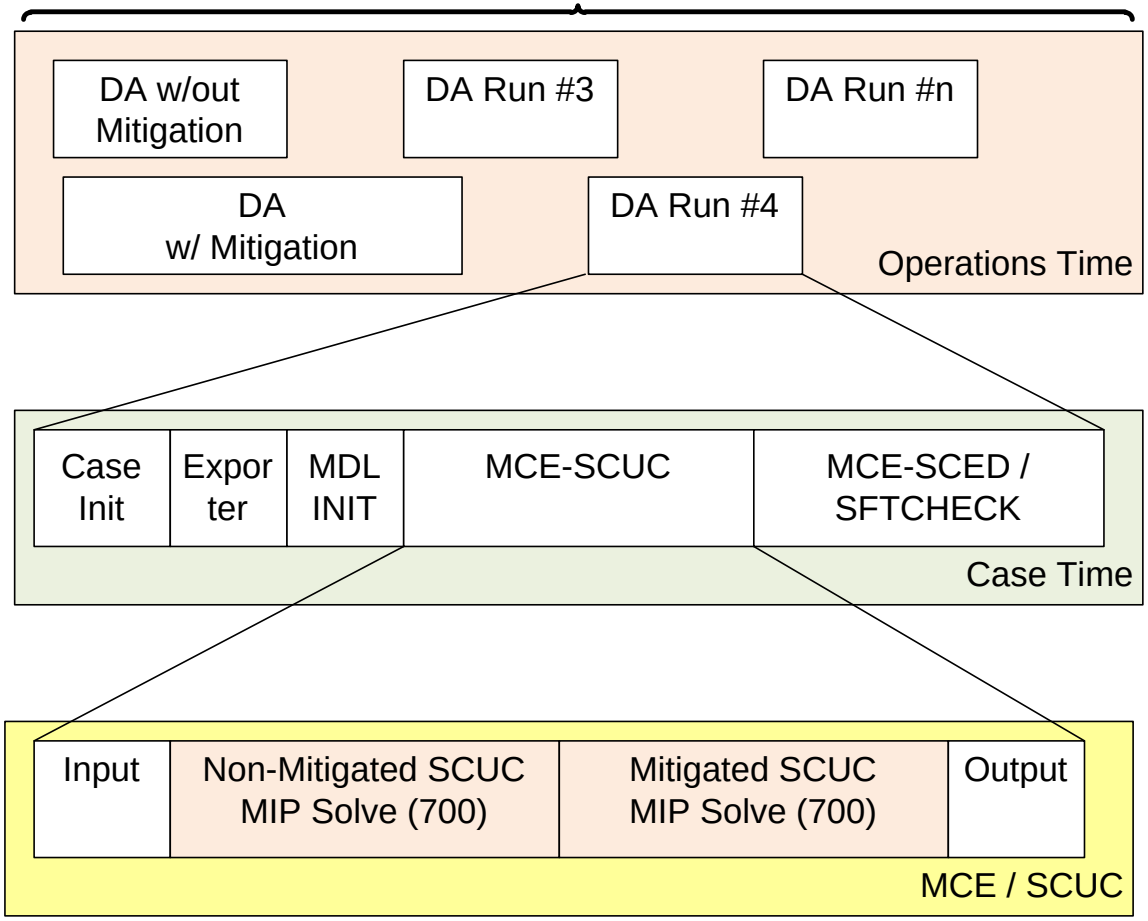
Path From Research to Deployment:

The art and science of practical optimization



Business Use Case: Wholesale Electricity Market

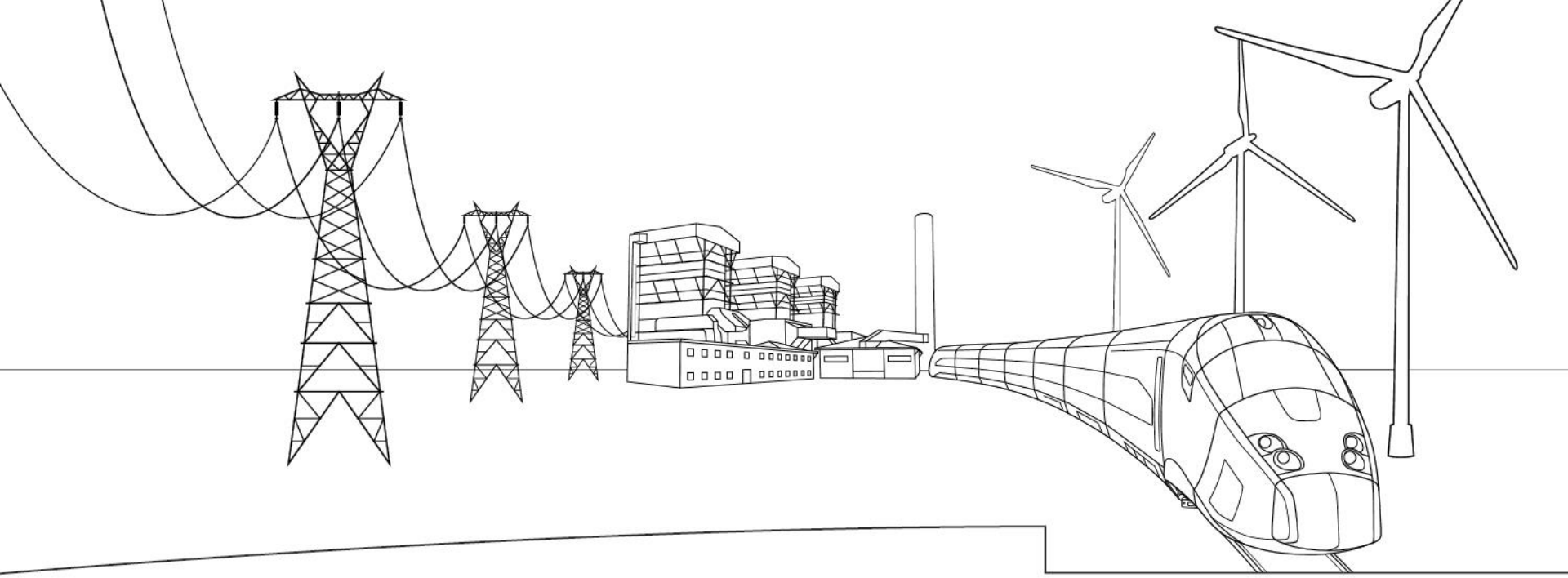
Day-Ahead Market Clearing



R&D Directions

Optimization applications

- Extended Problem Complexity:
  - Risk-based decisions
  - Multi-level & distributed decision: coordination, aggregation
  - Extended domain: gas-electric coordination,
- Improved optimization technology:
  - MIP: hot-start, heuristics
  - Stochastic/robust optimization
  - Post-solution assessment & suggestions
- IT/OT Integration
  - Visual analytics
  - High performance computing



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