Use of Cloud Computing for Power Market Modeling and Reliability Assessment

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Outline

- About NEG and ENELYTIX

- Why Cloud

- Energy Market Modeling on the Cloud

- ENELYTIX and PSO

- Benefits of ENELYTIX

- Challenges with cloud solutions

- Next Steps

About NEG and ENELYTIX

- **Alex Rudkevich** and **John Goldis** started NEG in 2012 with a mission to modernize power market modeling through the use of commercially available High Performance Computing

- **Russ Philbrick,** formerly with Alstom T&D, started Polaris in 2010 to develop a market simulator capable of addressing the evolution in the resource mix and operational/planning realities of the power industry

- ENELYTIX is a result of the partnership between **Newton Energy Group** (NEG) and **Polaris Systems Optimization** (Polaris)
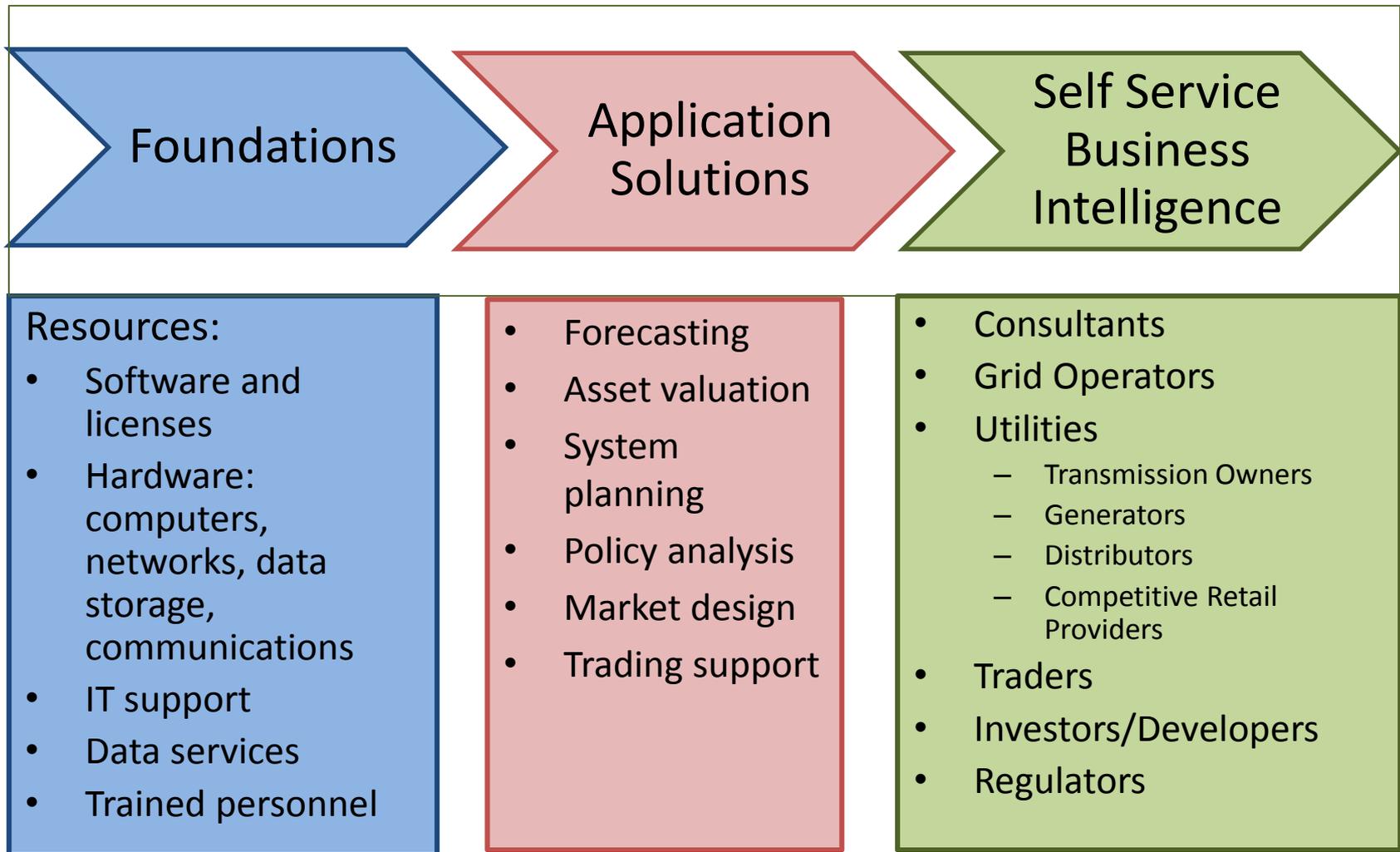
Why Cloud?

- Allows NEG to provide a comprehensive suite of services
  - Software
  - Hardware
  - IT
- Allows customers to leverage cloud resources through ENELYTIX and obtain major productivity gains at affordable costs
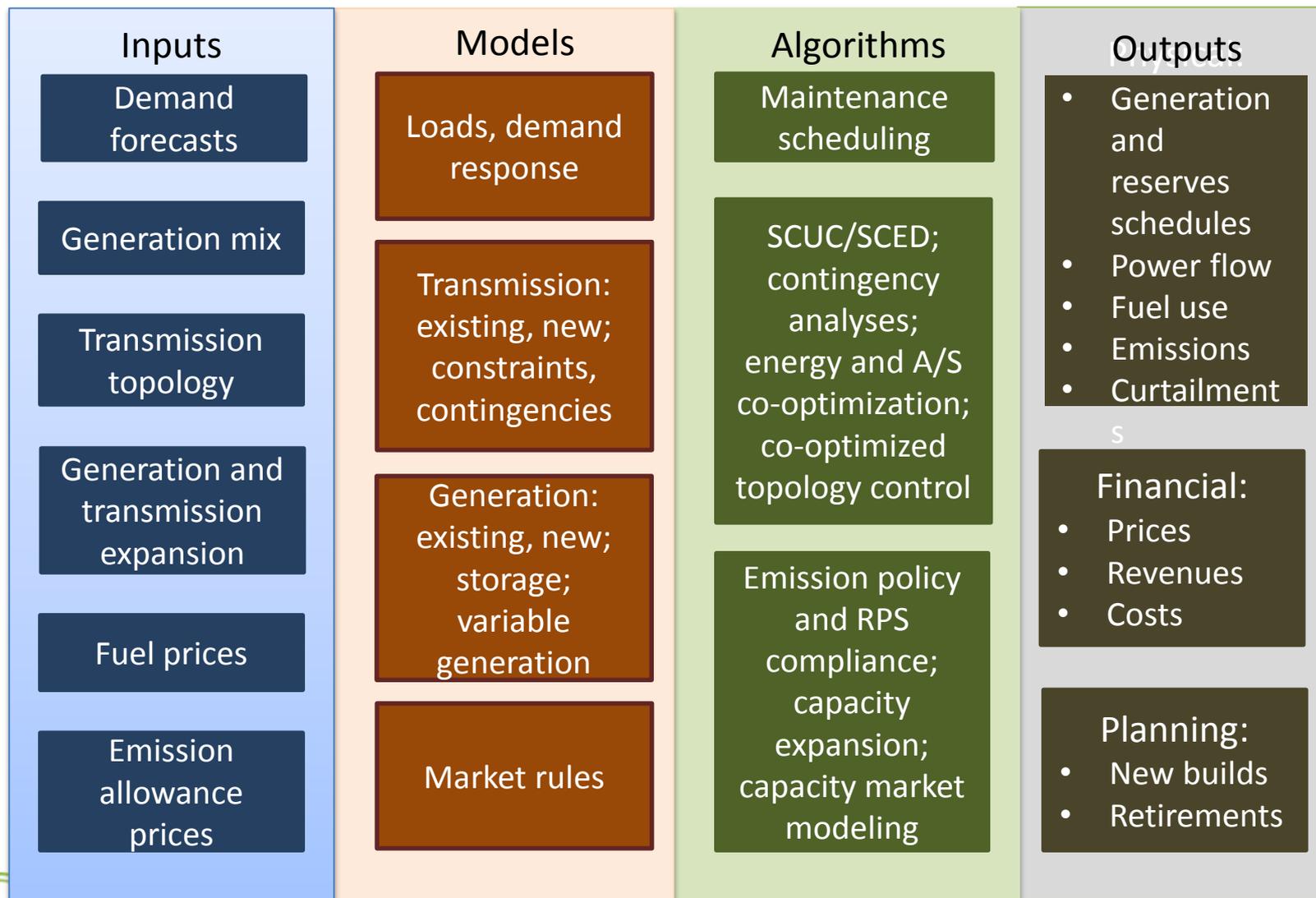
Energy Market Modeling on the Cloud

- Energy market simulations are computationally complex

- Simulations can be partitioned and parallelized

- Licenses are typically non-scalable as they are structured on a per-user or per-machine basis
  - Parallelization requires scalable hardware and software

- Cloud providers offer hardware on a usage basis

- With our partners (Polaris, AIMMS, IBM) we developed a usage-based pricing model for the software, creating an opportunity for ENELYTIX

ENELYTIX is a SaaS designed to help users run their energy market modeling business reliably and efficiently

Foundations → **Application Solutions** → **Self Service Business Intelligence**

Resources:
- Software and licenses
- Hardware: computers, networks, data storage, communications
- IT support
- Data services
- Trained personnel

- Forecasting
- Asset valuation
- System planning
- Policy analysis
- Market design
- Trading support

- Consultants
- Grid Operators
- Utilities
  - Transmission Owners
  - Generators
  - Distributors
  - Competitive Retail Providers
- Traders
- Investors/Developers
- Regulators

PSO, a MIP-based Simulation Engine

Inputs	Models	Algorithms	Outputs
Demand forecasts	Loads, demand response	Maintenance scheduling	Physical • Generation and reserves schedules • Power flow • Fuel use • Emissions • Curtailments
Generation mix	Transmission: existing, new; constraints, contingencies	SCUC/SCED; contingency analyses; energy and A/S co-optimization; co-optimized topology control	
Transmission topology			
Generation and transmission expansion	Generation: existing, new; storage; variable generation	Emission policy and RPS compliance; capacity expansion; capacity market modeling	Financial: • Prices • Revenues • Costs
Fuel prices			
Emission allowance prices	Market rules		Planning: • New builds • Retirements

ENELYTIX Services

Project simulation requirements

Simulation Task 1

Simulation Task m

Simulation Task M

Simulation ready data

Market Model Database

Automatic scenario generation, parallelization, scalable on-demand machine provisioning, run management, post processing and reporting

Scenario 1 — Segment 1, Segment 2, ••• , Segment K — PSO

Scenario 2 — Segment 1, Segment 2, ••• , Segment K — PSO

Scenario N — Segment 1, Segment 2, ••• , Segment K — PSO

Post processing

Reporting analytics, OLAP, visualization, drill-down, side-by-side analysis in Excel-based environment

Power Market Explorer

IT services: security, user authentication and access management, usage tracking, data encryption, storage and archiving

ENELYTIX Applications

- Valuation of assets (physical or financial contracts)
  - Cash flow projections under various scenarios

- Transmission planning
  - Assessment of physical flows, economic and environmental impacts of transmission projects. Cost-benefit analysis

- Policy analysis, market design
  - Simulation of the impact of changing regulatory policy, market /operational rules on market performance. Cost-benefit analysis

- Generation scheduling, trading support
  - Detailed simulations of system operations and economics under multiple scenarios with relatively short-term horizons (hour-ahead to month-ahead)

- Modeling of variable generation, distributed generation, demand response participation in markets for energy and ancillary services
  - Hourly and sub-hourly simulations of market operations under various inputs and market design scenarios

- Reliability assessments
  - Feasibility assessment of the system using Monte-Carlo generated scenarios
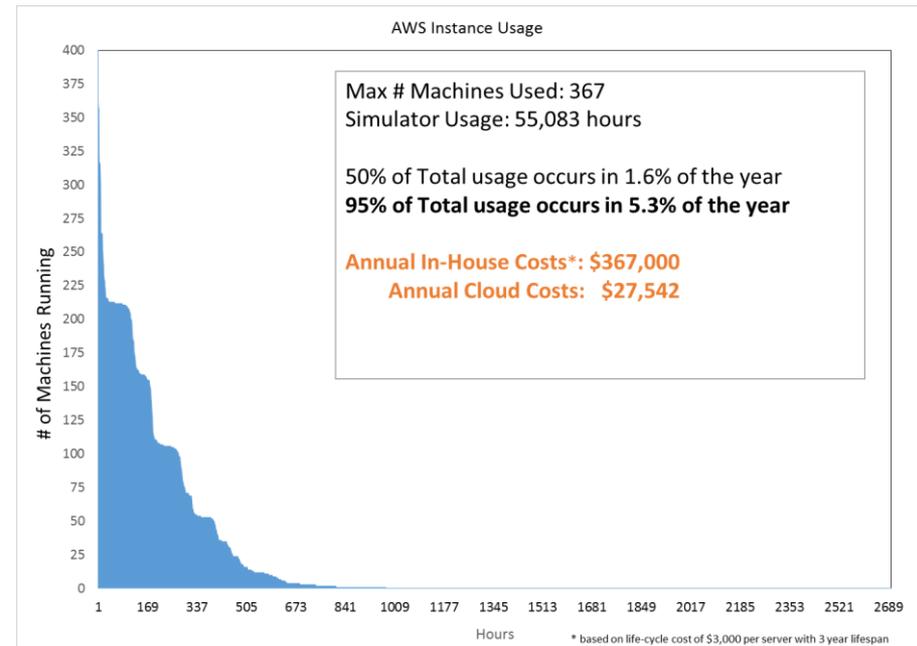
ENELYTIX Benefits

- Affordable Scalability

- Improved productivity and turn-around time

- Comprehensive IT infrastructure

- Making "Big Data" explorable

Affordable Scalability

Actual usage pattern for a customer
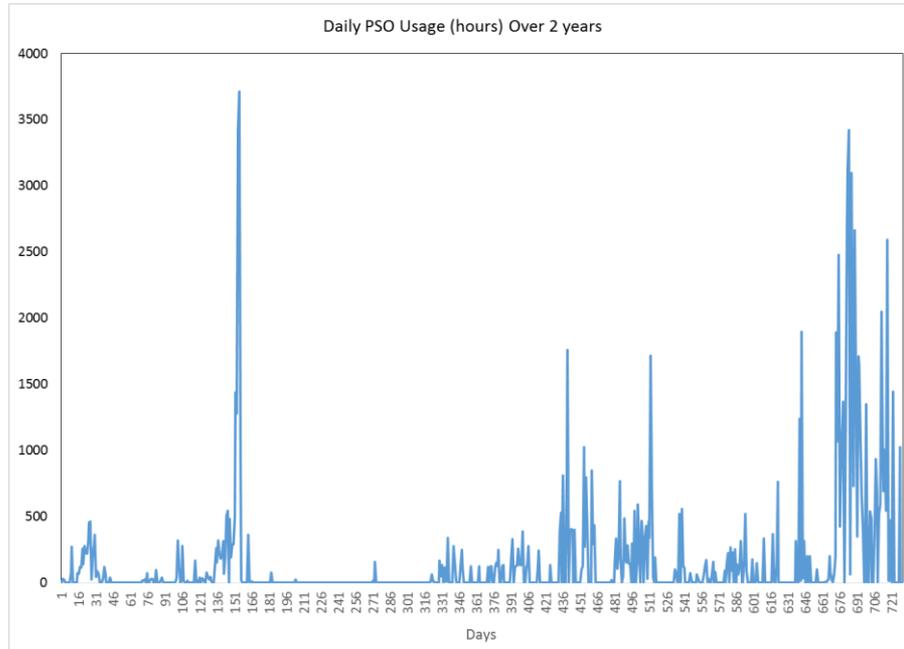
Cloud makes scalability affordable

Daily PSO Usage (hours) Over 2 years

AWS Instance Usage

Max # Machines Used: 367
Simulator Usage: 55,083 hours

50% of Total usage occurs in 1.6% of the year
95% of Total usage occurs in 5.3% of the year

Annual In-House Costs*: $367,000
Annual Cloud Costs: $27,542

* based on life-cycle cost of $3,000 per server with 3 year lifespan

Improved Productivity & Turn-Around Time

Statistic	1 year PJM Simulation, parallelized into 53 segments (1 week each)
Total Time (hh:mm)	36:46
Avg. Time per Segment (mm:ss)	41:27
Min Time per Segment (mm:ss)	31:37
Max Time per Segment (mm:ss)	56:21 → Turn-around time for simulations
Machine Properties	using c4.xlarge instance on AWS (4 vCPUs, 7.5GB memory, Intel Xeon E5-2666 v3 chip, 2.9GHz max clock speed).

- Any number of these simulations (multi-year, multi-scenario studies) will complete in under an hour
- Users relying on scalable cloud-based services accomplish much more in 1 hour than users relying on in-house solutions can do in a day
- With cloud-based scalability, MIP-based simulators deliver results faster than outdated and imprecise heuristic based tools
  - More robust, MIP-based simulators are generally slower than heuristic based simulators

Comprehensive IT

- Any IT service that could be needed is provided on demand

- Easy management for all customers
  - Single set of standards for all IT services

- Modern hardware
  - Updated by Amazon/Microsoft on a regular basis

Explorable Big Data

- Simulations generate hundreds of gigabytes of data

- Analytic needs are wide ranging and varied across users

  - Self-Service Business Intelligence (BI) is the natural approach to support these requirements

  - Parallelizing simulations demands parallelizing post processing

- Distributed cloud database services and custom OLAP cube solutions deliver scalable BI to support big data needs

Cloud Deployment Challenges

- Developing for cost-efficiency
  - Virtual hardware (hard drives, storage, compute)
  - Virtual software (database management, process management, general code efficiency)
- Managing scalability
  - Resource interruptions (partial/full)
  - Communication (cloud-cloud, cloud-ENELYTIX, ENELYTIX-user)
- Big Data
- Addressing Security Concerns

Developing for Cost Efficiency

- In the past, physical memory and hard drive space was limited

- With cloud services, hard drives, memory and compute capacity are easily accessible but have to be efficiently managed
  - Compute resources are charged on a whole hour basis

- Software processes have to be scheduled and planned around compute costs
  - Partitioning to maximize compute usage
  - Efficient provisioning of compute and storage resources depending on simulation size and complexity
  - Efficient code to minimize bandwidth of databases and web servers

Managing Scalability through Redundancy and Automation

- Developing with redundancy is required for consistent performance
  - network issues
  - database connectivity
  - Known unknowns (partial outages, extended downtime, web server interruptions, etc)
- With many simulations running in parallel – something will go wrong. Automated error handling is critical
  - Unexpected slowdown in run time
  - Sufficient Compute Resources
    - instance capacity
    - Memory/Disk space

Addressing Security Concerns

- Encryption at Rest

- Encryption in Transfer

- Secure APIs

- Subnets and VPC

- Closing external ports on EC2 resource

- IP range restrictions

- Amazon Inspector

Next Steps

- Develop distributed OLAP Cube processing across AWS

- Offer spot instances to customers with flexible deadlines

- Integration of new models
  - Natural gas pipeline optimization systems
  - Capacity Expansion

- Support more complex workflows
  - Automated simulation output to input
  - Iterative message passing between simulations

For More Information

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