Ontario Centers of Excellence

Distributed Energy Storage

Challenges & Opportunities

Toronto, Ontario Canada

Ontario Utilities Essential to DES Adoption

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Safe Harbor / Disclaimer

Due to the futuristic nature of the subject matter/discussions, the views expressed herein are forward looking and may or may not be supported by policy, regulations, market direction and/or operating practices either currently in place or in the future.

The views expressed are the author's very own and not that of any affiliated entities or organizations.

About Hydro One

Assets - $12.0 billion
Revenue - $4.7 billion
Territory – 647,000 sq. km
Employees – 4300

Transmission

Ontario Coverage – 97%

52 Large Utilities
113 Large Direct Customers
26 USA/Canada Interconnections

Assets (500/230/115 KV)

Overhead - 28,600 ckt-km ;
Underground cables - 272 ckt-km
Stations - 275

Peak Demand – 25,000 MW

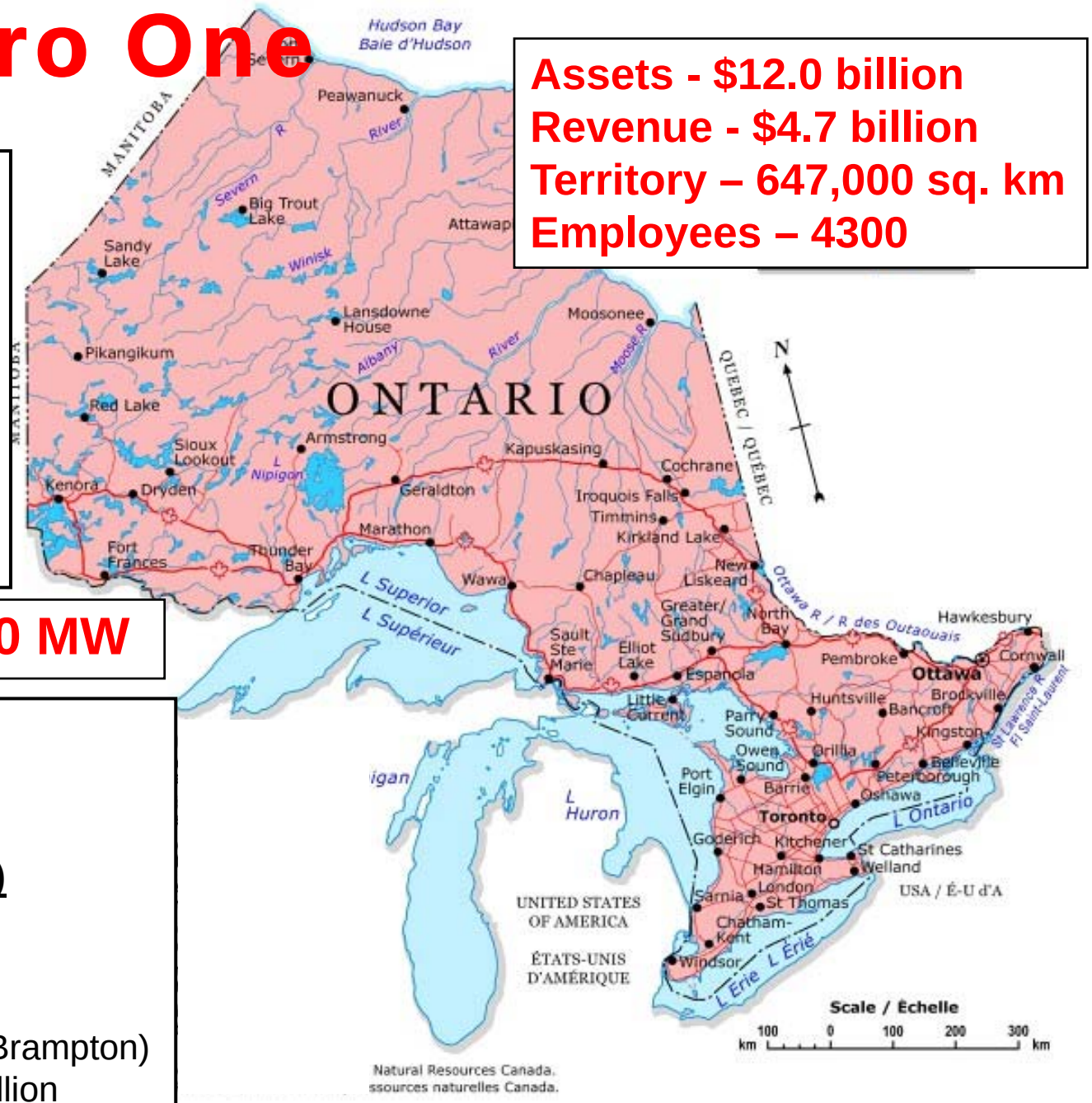
Distribution

Ontario Coverage - 75%

40 Small (embedded) Utilities

Assets (44/ 27.6/ 13.8/ 8/ 4 kv)

Overhead - 123,000 ckt-km
MV Stations: 1035;
LV Transformers – 520,000
Urban load customers – 280,000 (Brampton)
Non-urban load customers - 1.2 million



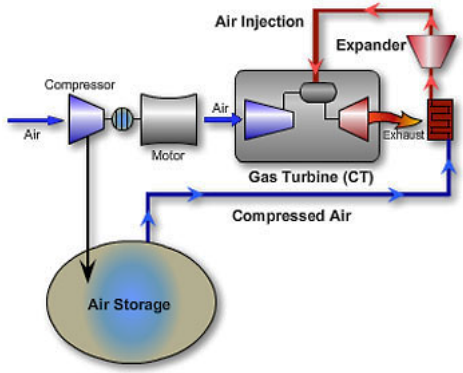
Potential Values of DES

- **Real-time Control**
  - MW/MVAR, Volt-VAR
  - Load – Generation Balance
- **Defer T&D Capital**
  - Stations, Feeders, Community
  - Higher Asset Utilization
- **Integrate Renewables**
  - Smoothing, Absorb “Spills”, Time Shifting
  - Firming – R.E. Unit commitment
- **Energy Arbitrage**
  - Ancillary Services
  - Congestion Relief

Storage Technologies

Liquid Air

10MW / 100MWh



Above Gr. CAES

10MW / 40MWh

Thermal

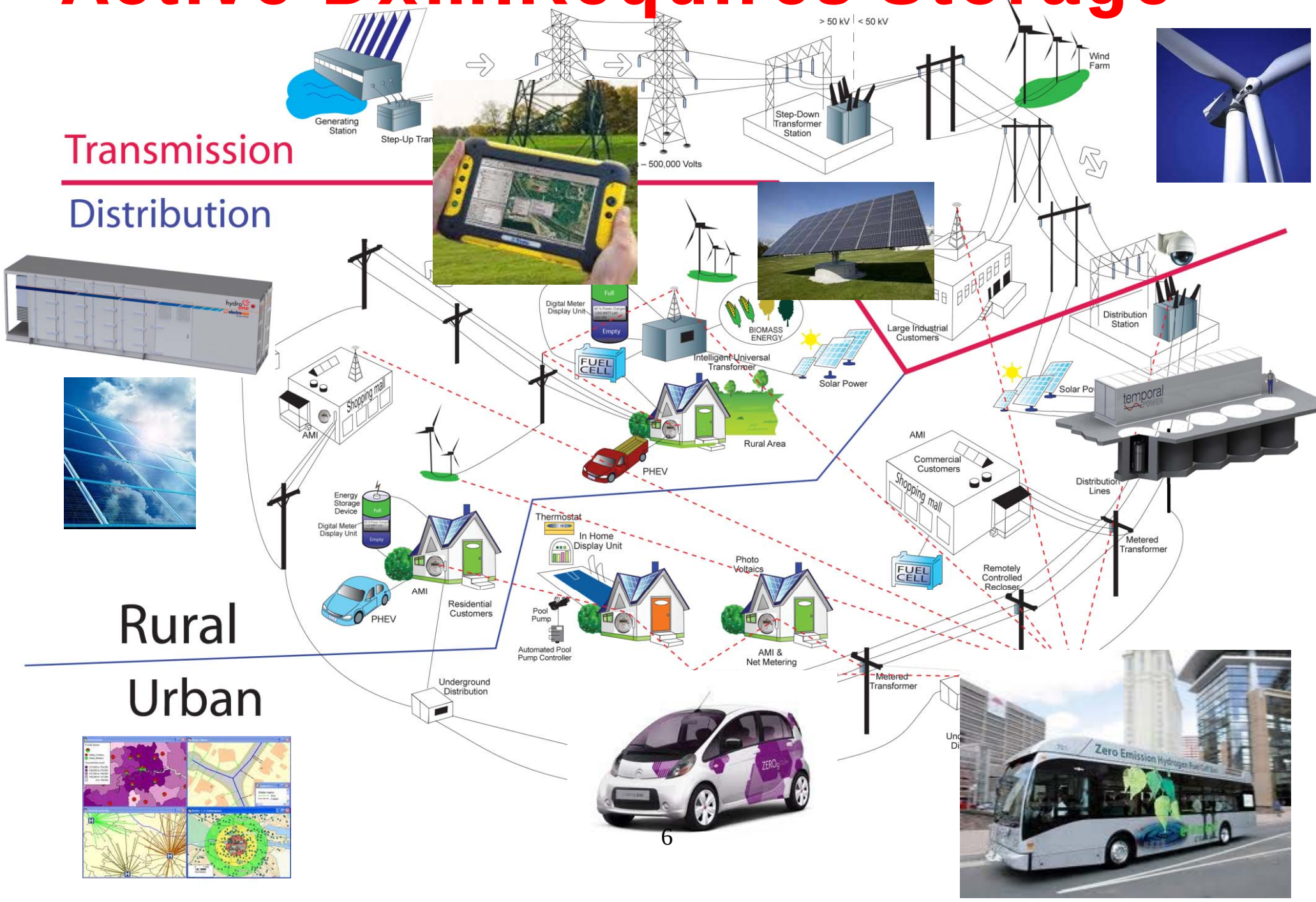
Ice; Water; Geo; Absorption Chiller

Flywheel

5MW / 500KWh

300KW/1.1 MWh ; 1MW/2MWh
25KW / 100KWh

Active Dx….Requires Storage



Value Attributes

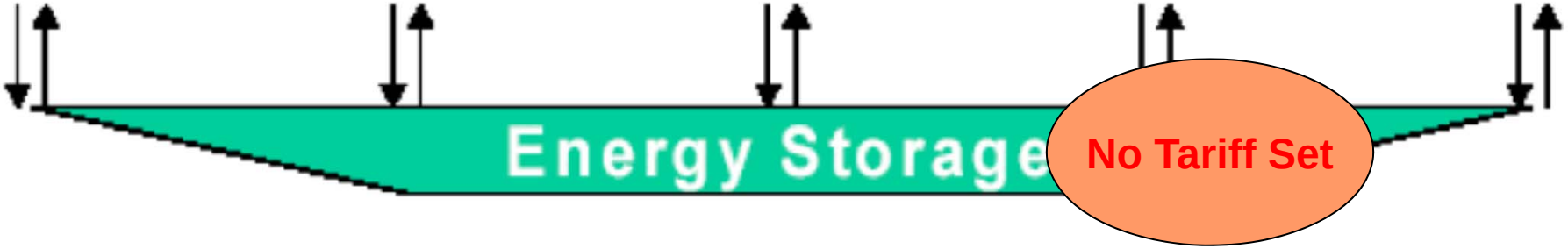
Single Asset: Multiple Values/Functions – Across Verticals

Ontario LDCs can own up to 10 MW

Electricity System Challenges

Volatility	Low Utilization	Congestion	Security	"Dirty" Power

Fuel	Generation	Transmission	Distribution	Services



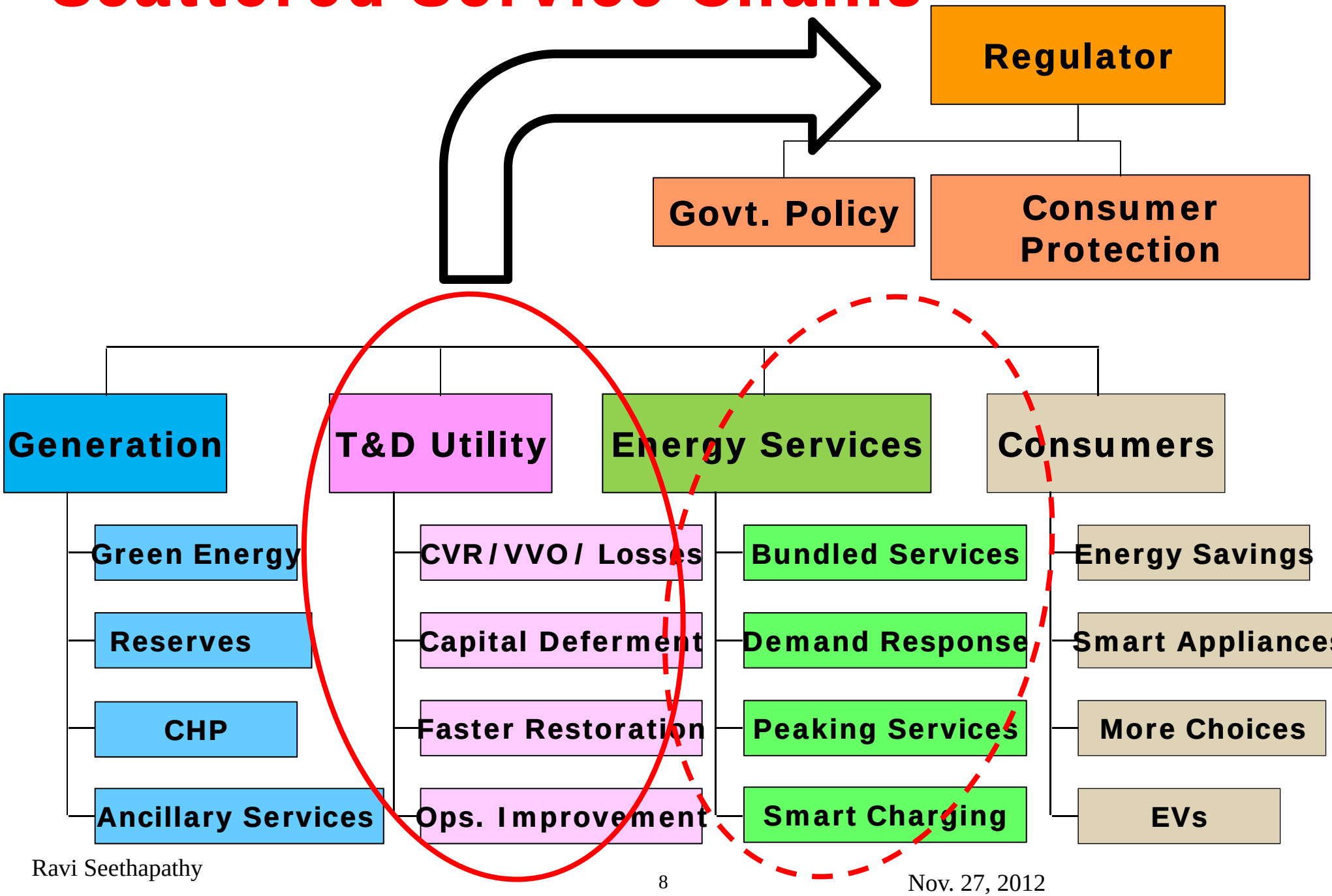
Hedge Risk	Baseload Arbitrage	Stability	Higher Utilization	Power Quality

Wind/Solar 'Smoothing'

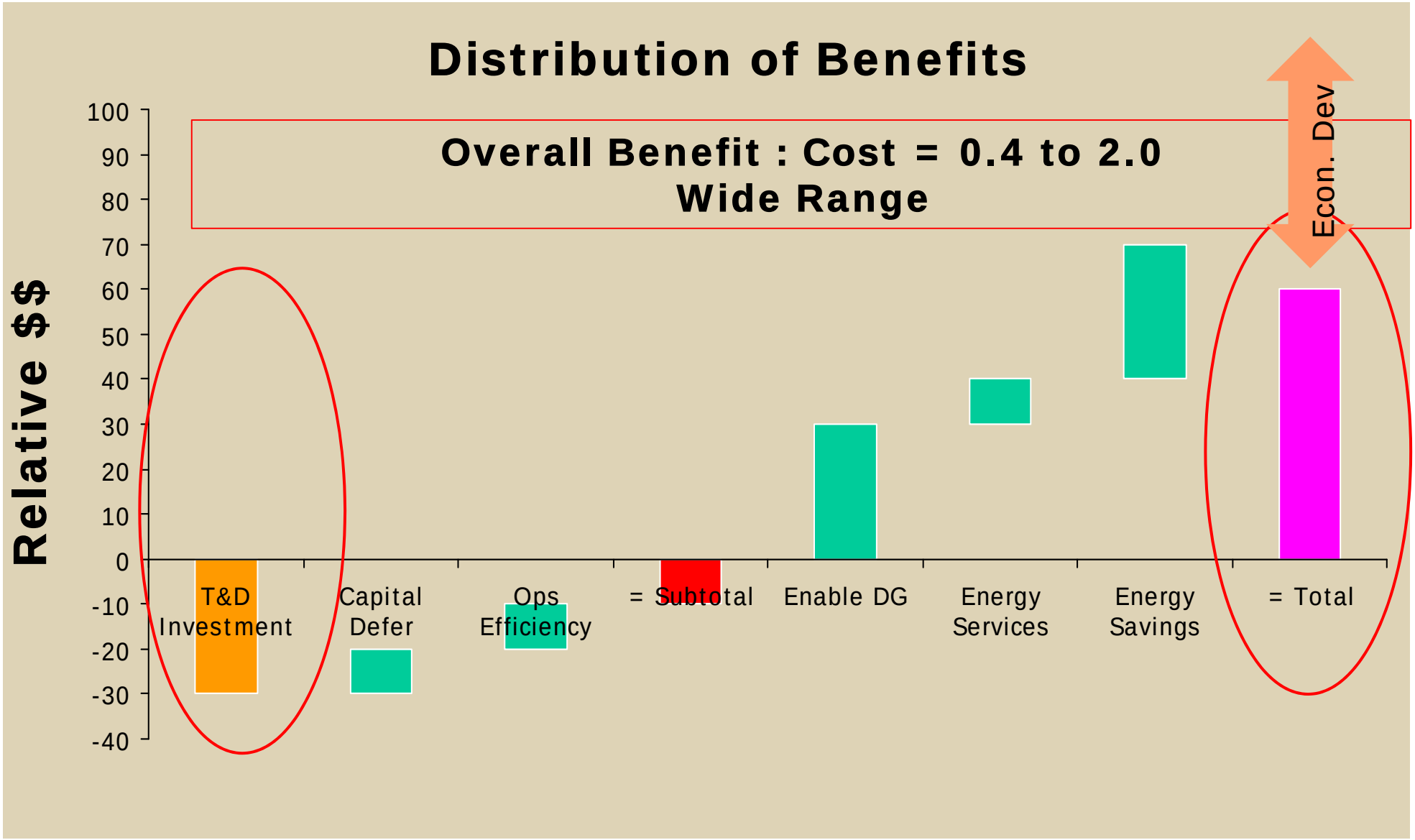
VAR Support

Energy Storage Value Offerings

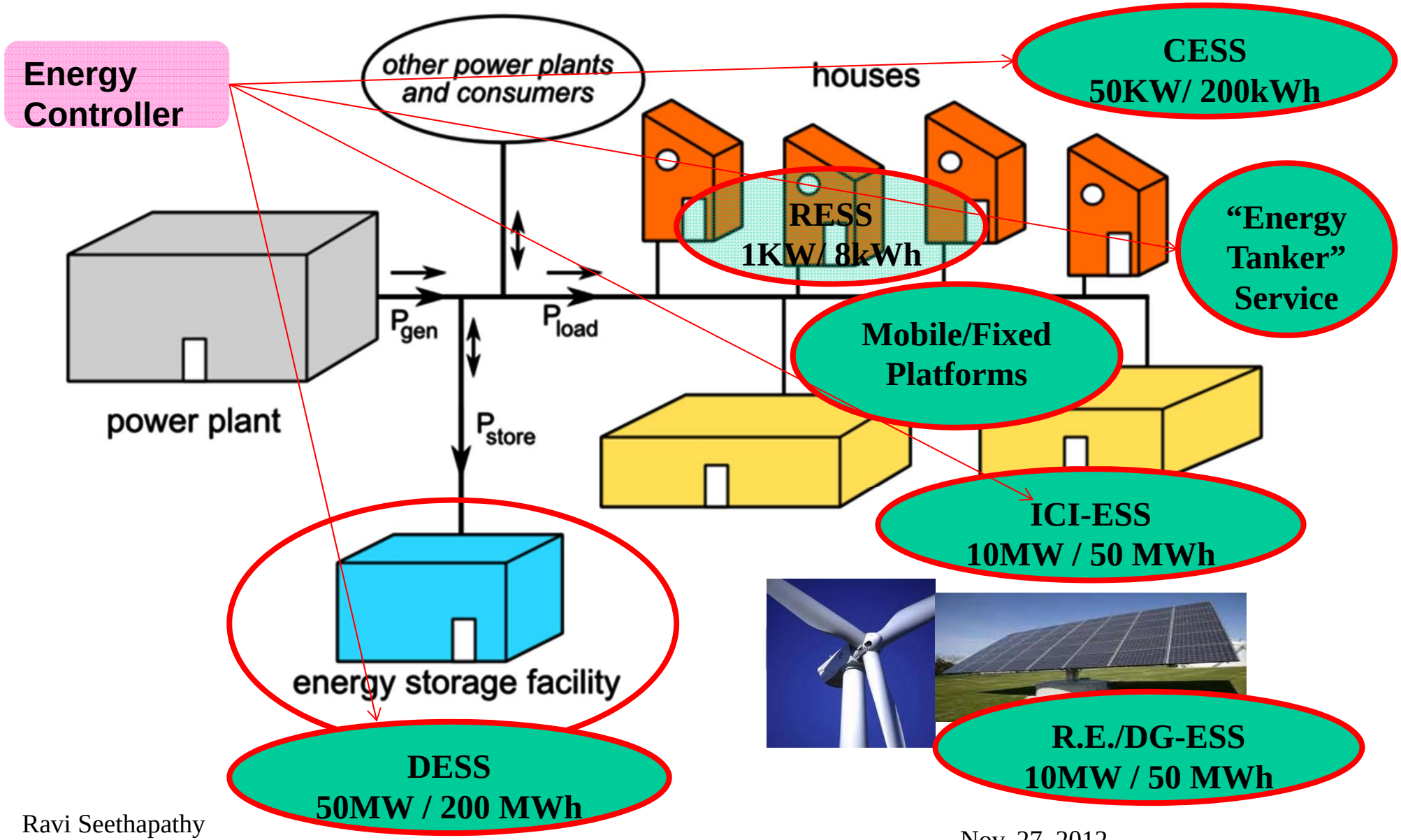
Scattered Service Chains



Scattered Benefits



Distributed Energy Storage: A Blueprint



Hydro One's Efforts To date

- **Pilot Demonstrations / Partnerships**
  - Flywheel and Li-Ion Battery Demo (under build)
  - LAES and CAES technology assessment (under way)
  - LAES and CAES Demo (need more $$ partners)
- **Specifications and Testing Requirements**
  - Generic Li-ION Battery Specs. (EPRI)
  - FAT and Commissioning test protocols (EPRI)
- **Studies**
  - Ice-Bear (OPA, RU)
  - Energy Storage in Microgrids (BCIT, UWO)
  - Wind/Solar - Smoothing, Ramp Control, Predictions
  - Electric Mobility Mapping (Pollution Probe, RU)
  - Geothermal Mapping (TAF, RU)

DES Adoption Challenges

- **Cost**
  - High Cost of DES
- **Technology**
  - Evolving
  - Not enough large scale pilots to gather experience
  - Need for standardized Specs/Requirements
- **Value for Integrating Renewables**
  - Smoothing, Absorb “Spills”, Time Shifting
  - Firming – R.E. Unit commitment
- **Energy Services**
  - Congestion Relief
  - Peak Shaving
  - Emergency Backup

Paths Forward for Ontario……

- **Regulator and Utilities**
  - How can innovation be effectively "regulated"
  - Acceptable risk in R&D investments
  - Foundational vs. Scaled investments
  - Incentivize "pooling" of R&D capital?
- **Policy**
  - Adopt Portfolio Standards
  - Drive Standards
  - Focused Fed./Prov. R&D
- **Industry**
  - Reduce cost of technology
  - Behind the Meter applications (solar, wind, load)
  - Firming Renewables

THANK YOU

Brief CV of Ravi Seethapathy

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Ravi Seethapathy, is Manager – Systems Innovation & Advanced Grid Development, at Hydro One Networks in Toronto, Canada and led the power systems technical architecture of its Advanced Grid System (Smart Grid) program and currently leads its Corporate RD&D efforts. He led the Corporate Smart Grid Strategy Taskforce in 2008 and from 2006 led the initial efforts in the integration of DER in the Hydro One Distribution system including creating the R&D network involving universities, associations and other forums.

Ravi has over 28 years of experience (in Hydro One/ erstwhile Ontario Hydro) in all fields of electric utility business and has progressively held leading positions in Research, Protection & Control, Field Operations, Hydraulic Generation and Transmission Operations, Generation Performance, Distribution Strategy and Planning, Mergers & Acquisition, Corporate Audit, Asset Management and Asset Strategies Divisions.

He has Chaired/served on many technical and other voluntary Boards such as Ryerson University, Canadian Club, Scarborough Hospital, TV Ontario, Engineers without Borders, Indo-Canada Chamber of Commerce and Shastri Indo-Canadian Institute Advisory Council. He co-chaired the "Canada-India S&T Mapping Study in 2004 which enabled the bilateral agreement in 2005.

Ravi sits on the Advisory Board of Ryerson University's newly created Center for Urban Energy, and on the Steering Committees of several M$ research projects of the Ontario Centers of Excellence. He sits as the Canadian expert on the IEA PVPS Taskforce on large-scale solar integration and on the International Microgrid Forum. He is the Canadian Representative of CIGRE Canada on the C6 Study Committee and sits on several of its sub-committees in Energy Storage, Rural Distribution, Electric Vehicles, and is an active Advisory Council Member (Power Delivery, Utilization, Energy Storage and SG Implementation) in EPRI, IEEE, Edison Institute and others.

Ravi currently serves as an Adjunct Research Professor at the University of Western Ontario. He is a Senior Member of the IEEE and a registered Professional Engineer in Ontario. He has co-authored many leading technical papers in Advanced Grid systems and actively lectures at Conferences and Universities. He is a Fellow of the Canadian Academy of Engineering.

He holds a B.Tech (Hons) in Electrical Power from IIT, India, an M.Eng in Electrical Power from University of Toronto and an MBA from the Schulich School of Business, York University, Toronto. He has received several citations and awards.