



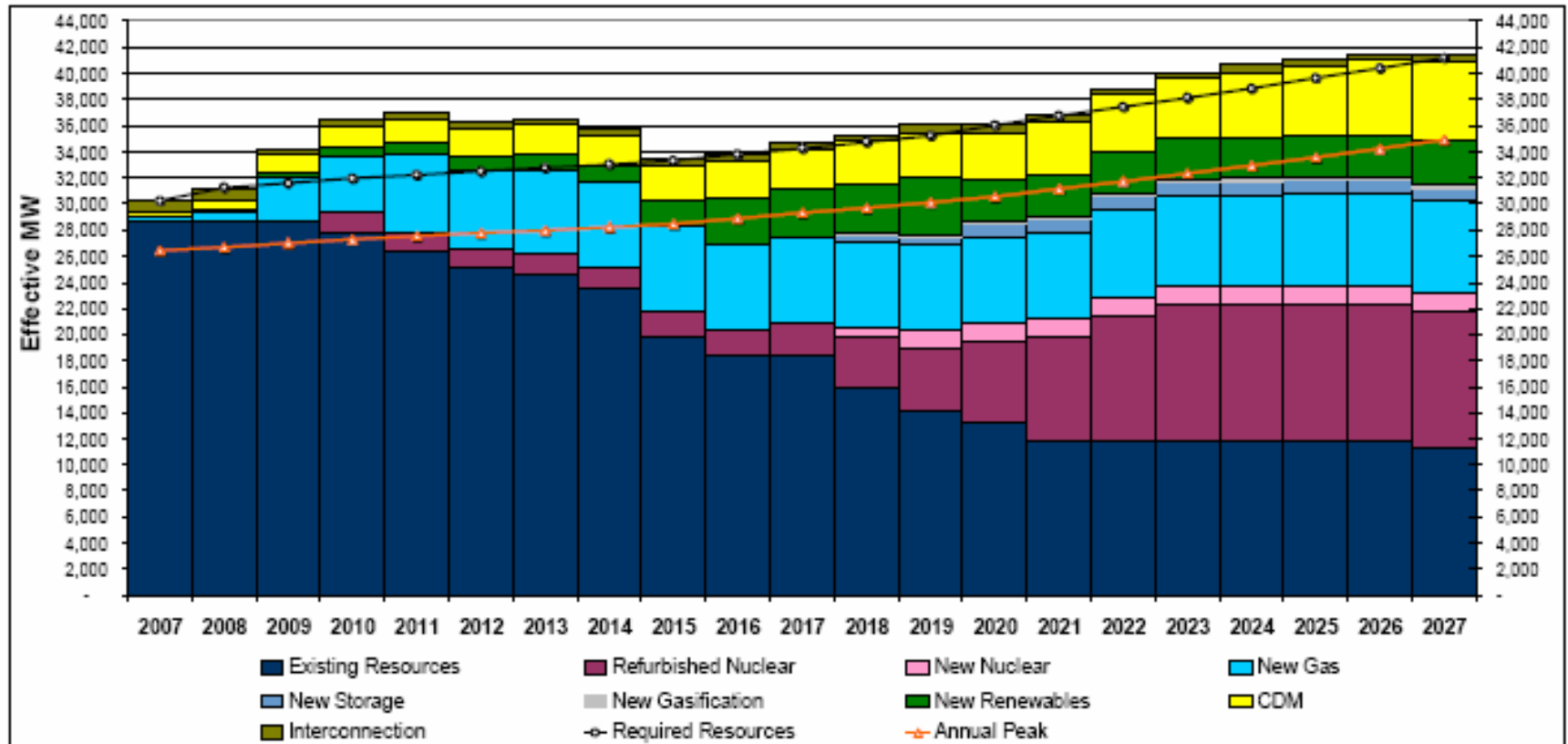
The Future of Energy Storage in the Evolving Canadian Electricity Supply System

Jim McDowall

■ What *is* energy storage?

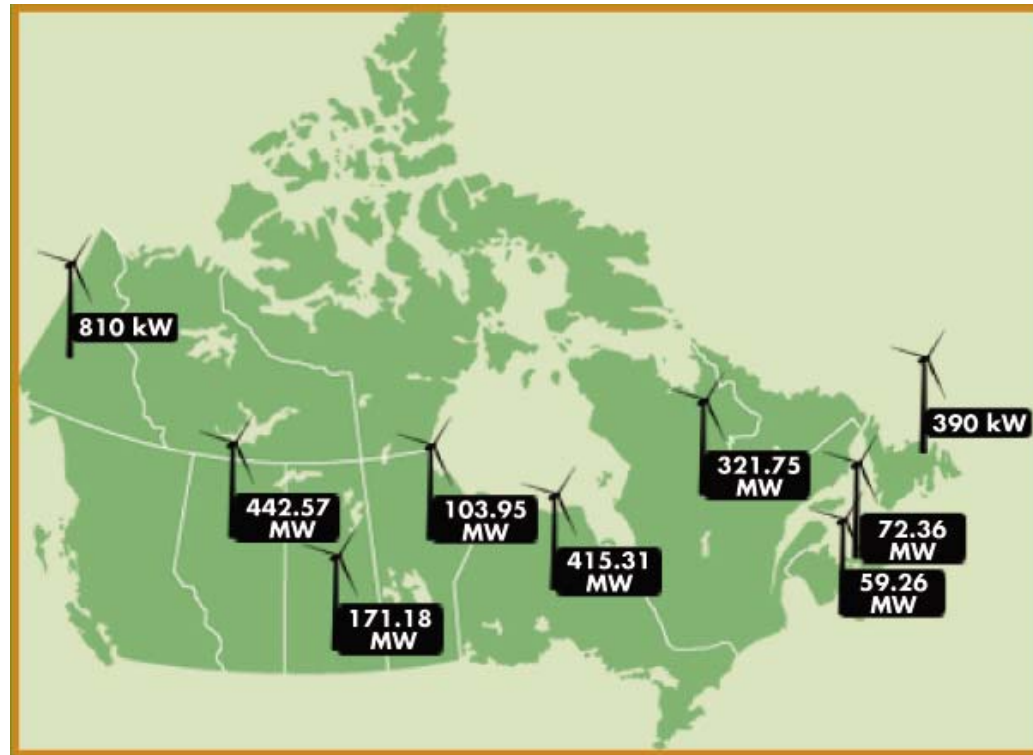
- **Systems connected directly to the electricity supply infrastructure, capable of absorbing and releasing electricity as required, to improve the delivery of electricity to consumers**
- **Aspects to be discussed**
 - Power system development
 - Non-hydro renewable energy
 - Arbitrage
 - Distributed energy resources / microgrids
 - Plug-in hybrid electric vehicles

Demand & generation – Ontario



Source: Ontario Power Authority
Integrated Power System Plan

Wind energy in Canada

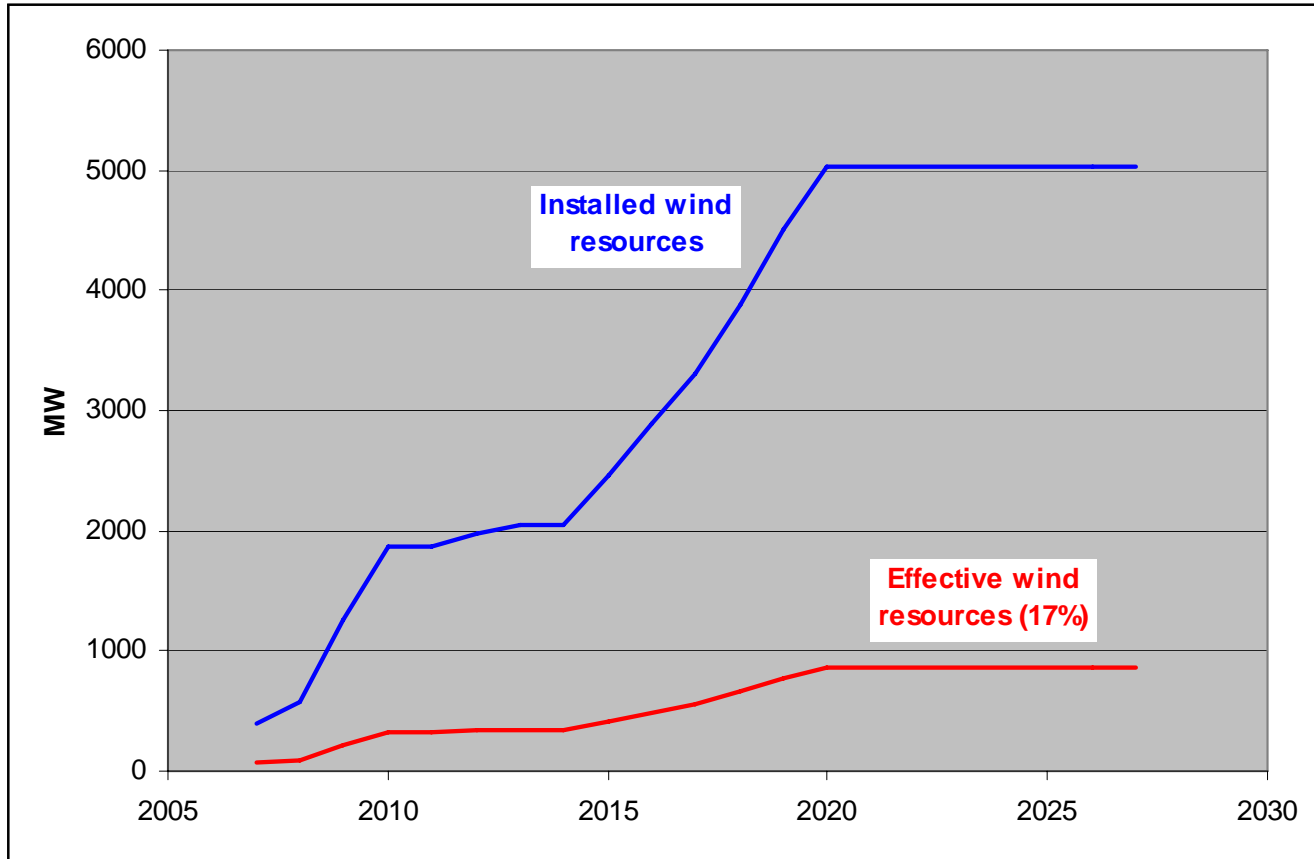


Source: Canadian Wind Energy Association

- Total nameplate rating of 1,588 MW in July 2007
- Nameplate rating is not the same as output!

Wind capacity factor – planning

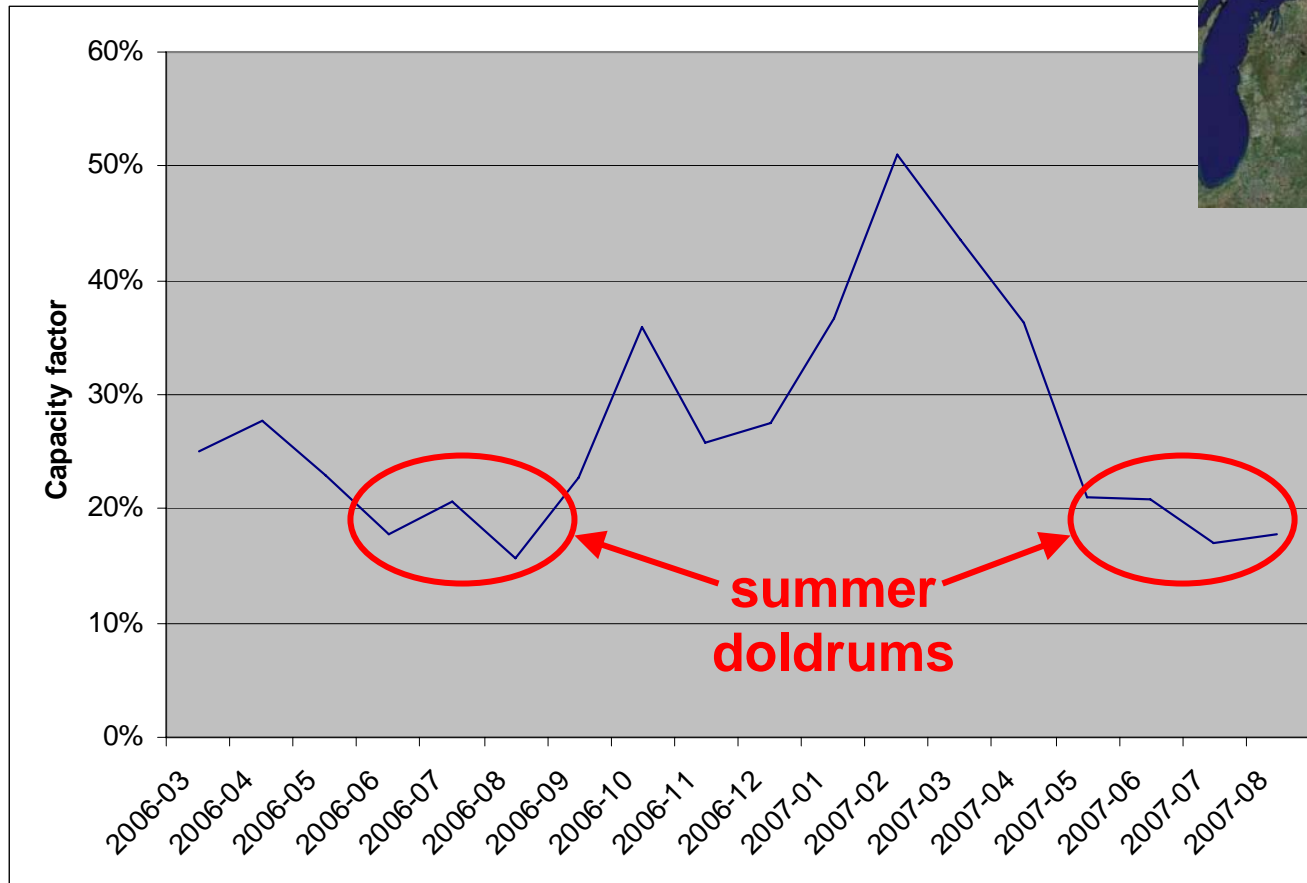
Ontario wind generation to 2027



Source: Ontario Power Authority
Integrated Power System Plan

Wind capacity factor – time of year

Amaranth I wind farm output, Melancthon, On

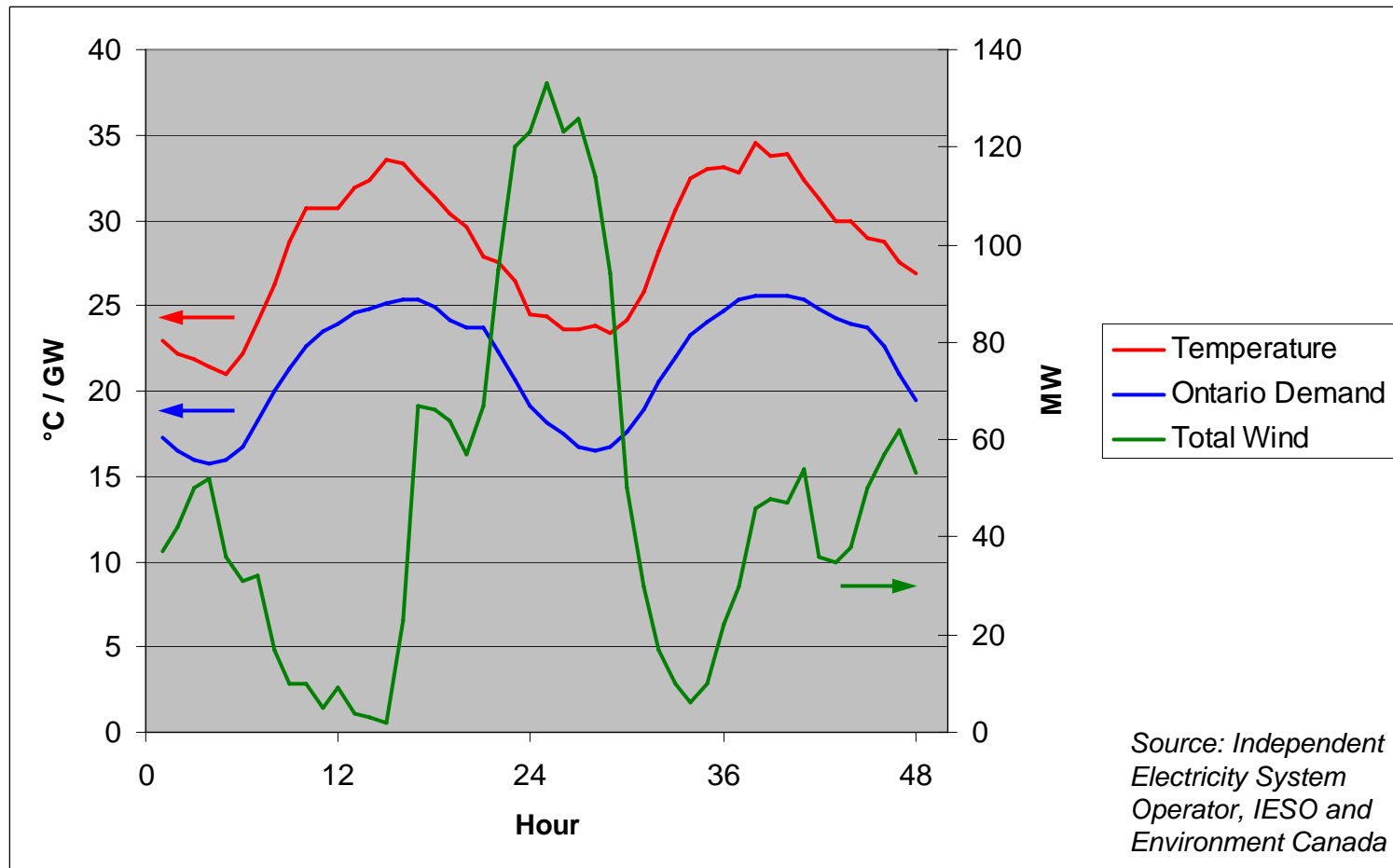


Source: Independent Electricity System Operator, IESO

- Note – Ontario is the only province with a summer peak

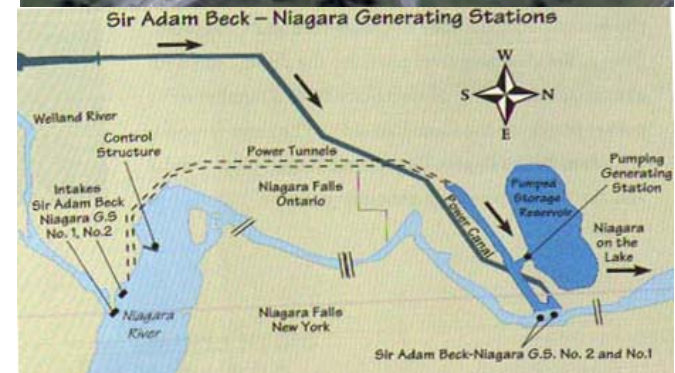
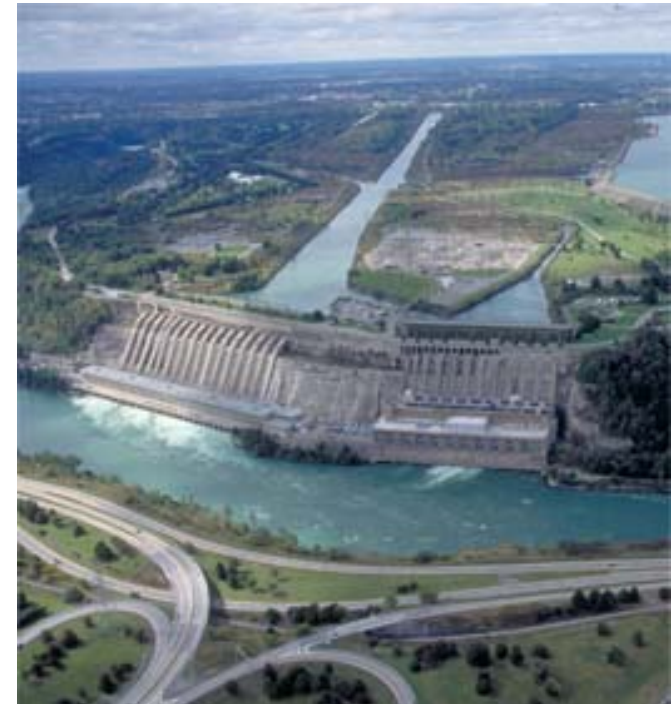
Wind capacity factor – time of day

Ontario wind output, August 1-2, 2007



Can energy storage fix the problem?

- **Bulk storage can overcome diurnal variations**
- **Adjust conventional hydro output**
- **Use of pumped storage**
 - Sir Adam Beck No. 1
498 MW (conventional)
 - Sir Adam Beck No. 2
1440 MW (conventional)
 - Pumping-Generating Station
174 MW pumped storage
- **Cost is a major factor**
 - California study indicates value of storage for wind firming is approx. US\$100 / kWh

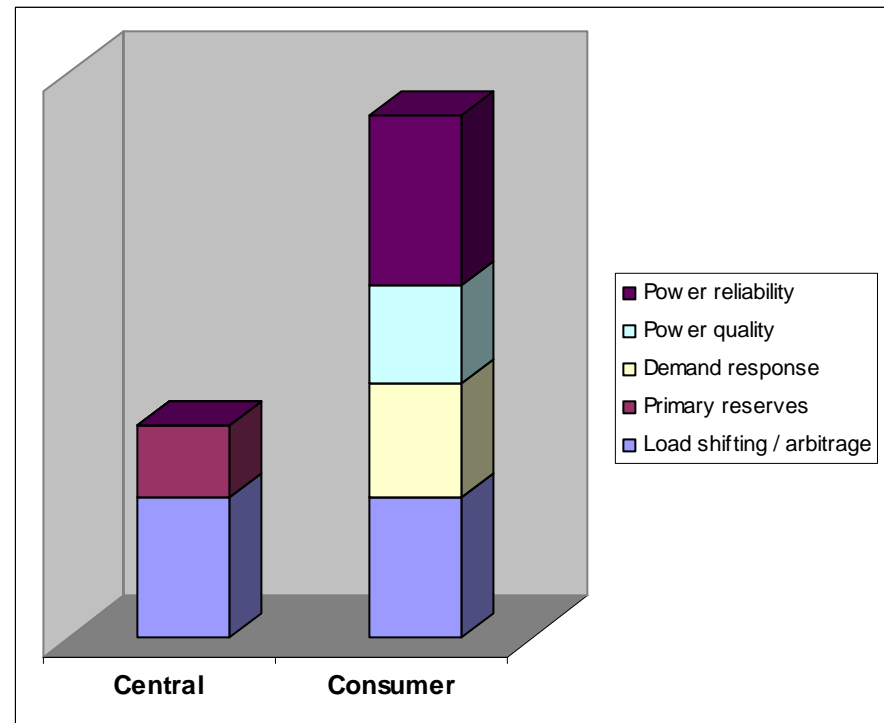


Value of storage for arbitrage

- **Ontario residents moving towards smart meters and time-of-use (TOU) pricing**
- **Ontario Energy Board rates (May 2007)**
 - 9.2 cents / kWh on-peak
 - 3.2 cents / kWh off-peak, including weekends
- **Arbitrage calculation**
 - 1 kWh storage at 80% efficiency yields 5.2 cents savings per weekday
 - \$13.52 per year, \$135 in 10 years
- **Not a good investment!**

High value storage

- **High value from storage can be realized by combining value streams**
- **Higher value closer to consumer**
(Actual values vary by user)



Distributed energy resources (DER)

- **Distributed...**

- Generation
- Intelligence
- Storage

- **Generation**

- Dramatic efficiency improvements with combined heat and power (CHP) systems

- **Intelligence**

- Utility control capabilities
- Smart meters
- Web-connected devices / appliances

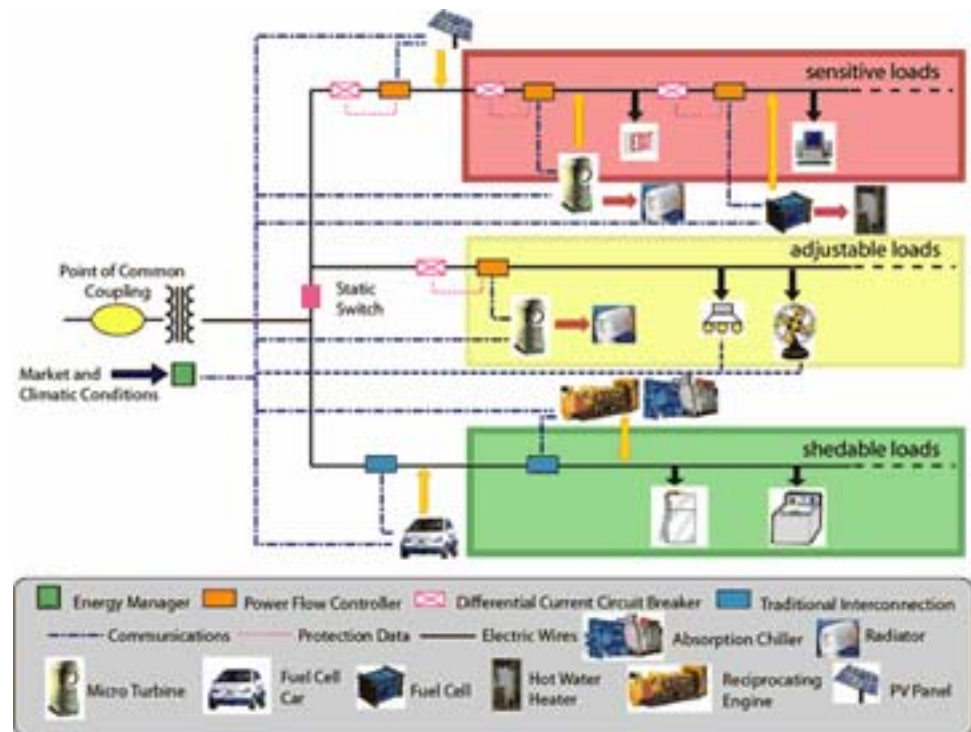


Implementation of DER

- **Incremental upgrade of existing grid**
- **Microgrids**
- **Smart residences**

Microgrids

- Normally grid-connected
- Embedded generation & storage
- Autonomous operation

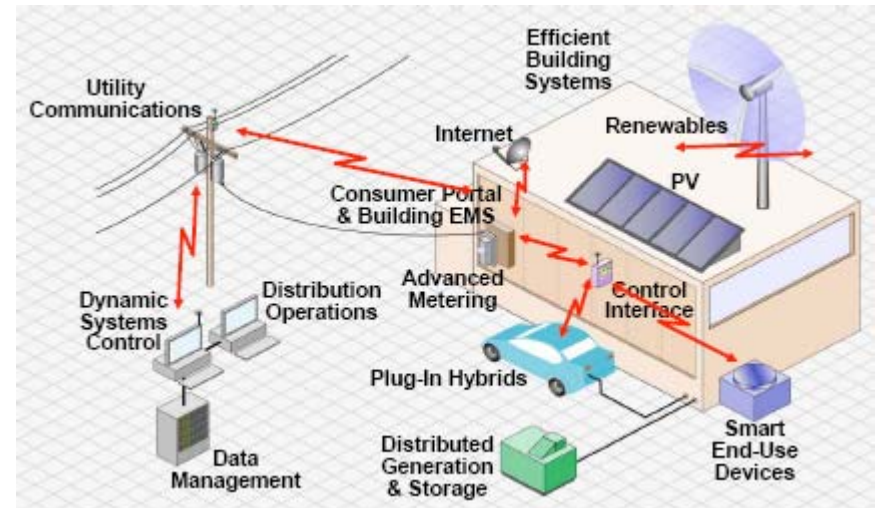


<http://certs.lbl.gov/certs-der-micro.html>

“Microgrids will not be competing with the centralized power system of today but with the erratic growth of that system in an environment hostile to its expansion.”

Smart residences

- Demand management / load control
- Integration of renewables e.g. rooftop PV
- Energy flow management through use of storage
 - Whole-house demand response
 - Sale of green power to utility
 - Power quality
 - Power reliability



Source: Electric Power Research Institute



Source: GridPoint

Energy storage requirements

General

- **Long calendar life**
- **High cycle life**
- **Maintenance-free / self-diagnostic**
- **Compact**
- **Safe**
- **Inexpensive**

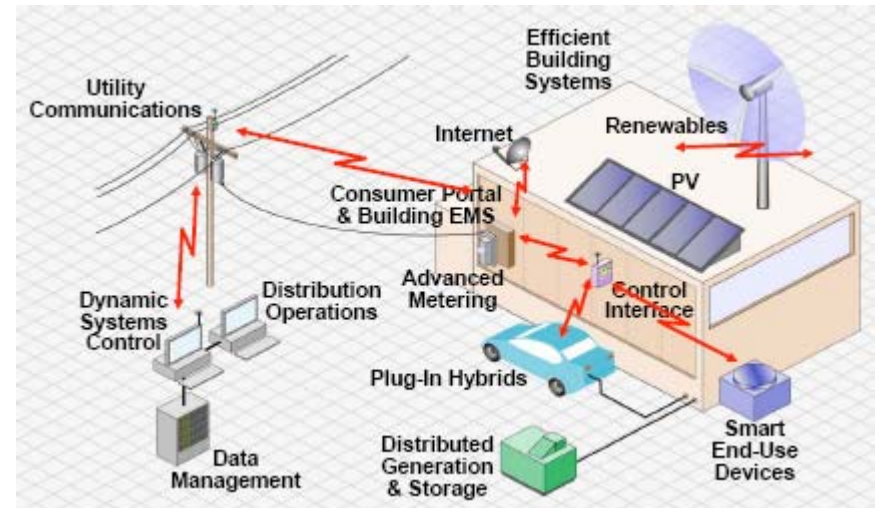
Application-specific

- **High power for short-duration discharges in microgrids**
 - Supply of load spikes
 - Ramping control for local generation
- **High energy for long duration in residential systems**
 - Matching PV output to demand peak

■ Matching a battery to the requirements

- **No battery meets all the requirements at present**
- **Considerable interest in lithium ion for these applications**
- **Concept of convergence between transportation and stationary power systems**

PHEV & V2G



- **PHEV success linked to Li-ion**
- **Smart charging will be an asset in grid management**
- **Extension of concept to bi-directional 10 kW link – V2G**
- **Possible payment by utility for reserve power**
- **End-of-life option – use of PHEV sub-module in residential energy management system**

Lithium ion options



TESLA MOTORS



Small format
Cobalt technology



Large format
Nickel-cobalt-aluminum technology



Small format
Iron phosphate technology

Summary

- **Evolution of Canadian electricity system will be a challenge**
- **Abundance of hydro power is a big help**
- **Distributed energy resources will be key**
 - CHP generation
 - Smart grid technologies
 - Energy storage
 - Watch out for PHEV progress and systems based on lithium ion
- **Expect fierce competition between lithium battery options**

■ Thanks for listening...

- **Jim McDowall**

jim.mcdowall@saftbatteries.com

(203) 985-2712