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Residential Energy Storage - Smart Grid Thermostats

David Urquhart – New Brunswick Power

Trevor Nightingale – National Research Council Canada

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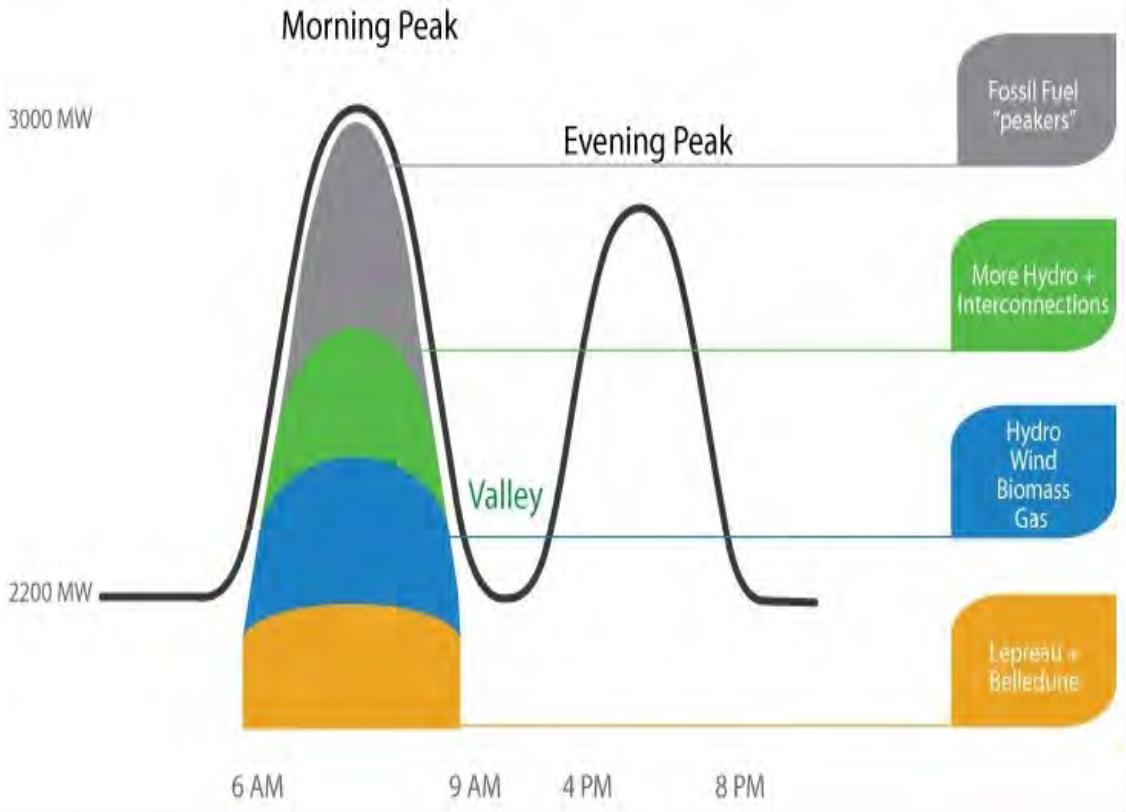
NB Power – Vertically Integrated Crown Corp. Utility

- Winter – Morning Peaking Load Profile (7:30 AM)
  - 3000 MW's Winter, 1000 MW's Summer
- Water Heater Rental (Res)
  - 250000 Water Heaters
  - 180 MW Morning Peak
- Electric Heat (Res)
  - 63% Electric
  - 47% Baseboard
  - 600 – 800 MW's
- Reduce & Shift Demand
  - 609MW's
    - 60% Efficiency
    - 40% Load Shifting



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NB POWER 2015

Customers
394,000

Distribution Lines
20,815 KM

Generating Capacity
Thermal = 1439 MW
Hydro = 889
Nuclear = 660
Combustion Turbine = 525

Wind
294 MW

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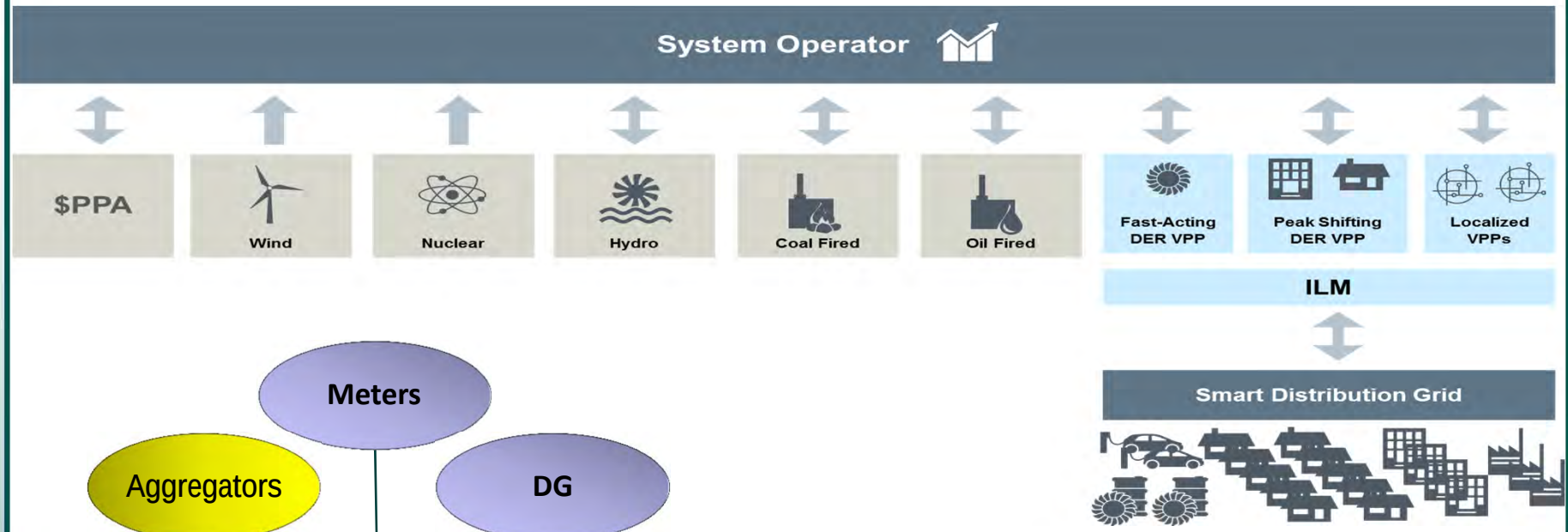
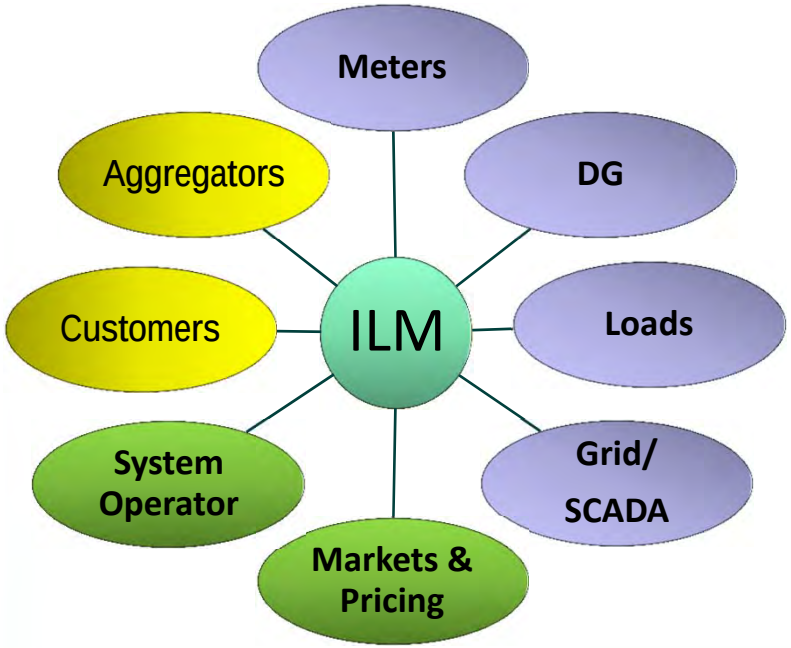
NB Power / Siemens Partnership





- 10 Year Smart Grid Development – 2012
- Organizational Transformation
- Siemens Compass Methodology
- 200 Projects (Initiatives & Technologies)
- 13 Value Packs (Logical Groupings)
- ILM – Integrated Load Management
  - OpenADR 2.0B

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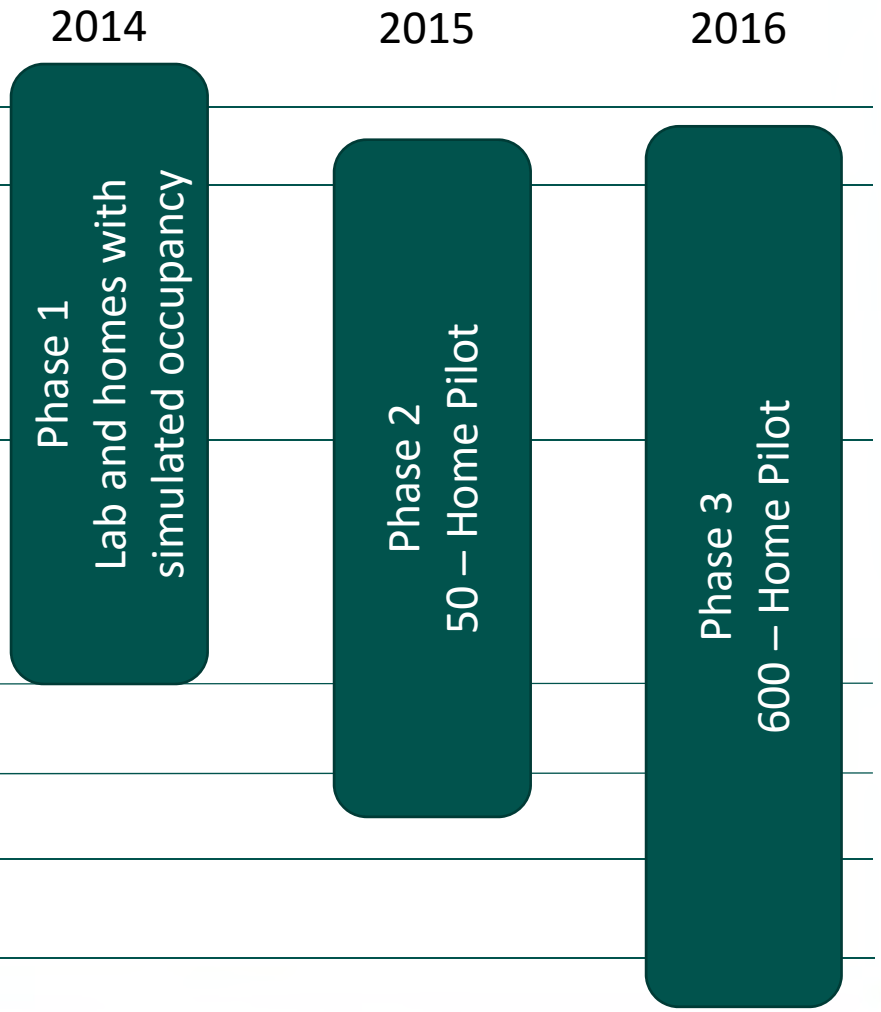
NBP / NRC / Siemens - Goals and KPIs

- Prove concept
- Power shift potential
  - Magnitude (kW)
  - Duration (hr)
- Rebound
  - Maximum power draw (kW)
  - Duration (hr)
- Energy penalty (kWh)
- Impact on thermal comfort
- Refine DR parameters
- Improve home selection



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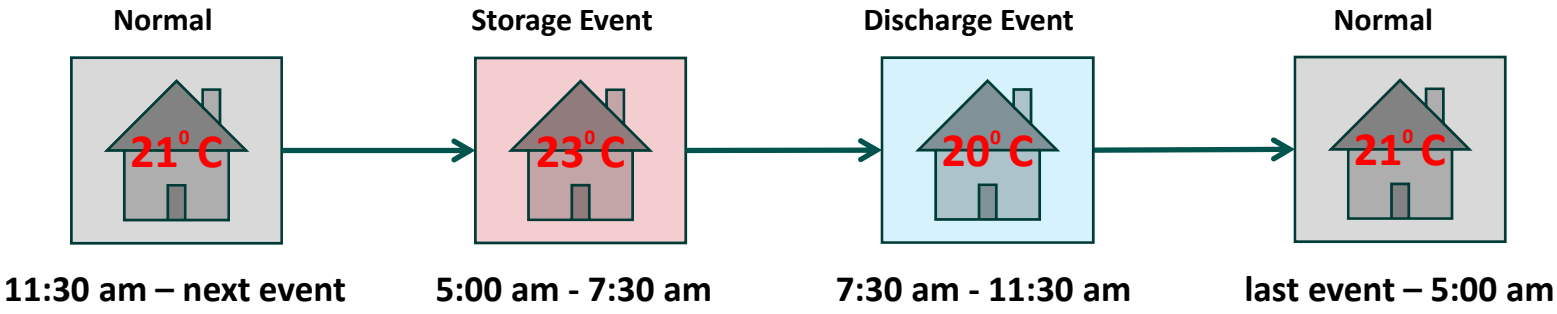
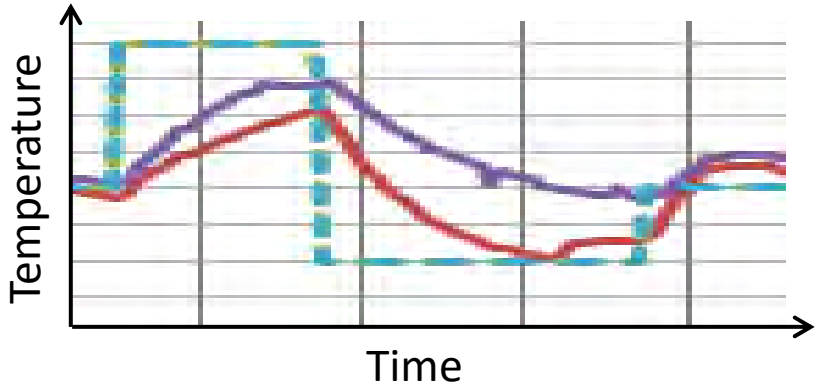
Concept and Approach





- **Storage**: Set-points increased up to 2ºC (heaters activated), electrical energy stored as heat in the building contents & structure
- **Discharge**: Set-points decreased 1ºC (heaters deactivate), temperature slowly drops, rate determined by thermal loads & envelope resistance
- **Transition** from Storage to Discharge before critical Grid peak

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Proof of Concept Testbed

NRC's Indoor Air Research Laboratory (IARL)

- Electrical baseboard & forced air natural gas heating
- Sensors, energy metering, and data logging
- Zoned control & monitoring
- Local weather station

Floor Area: 2,700 square feet

Electrical Baseboard Heating Capacity: 10.5 kW

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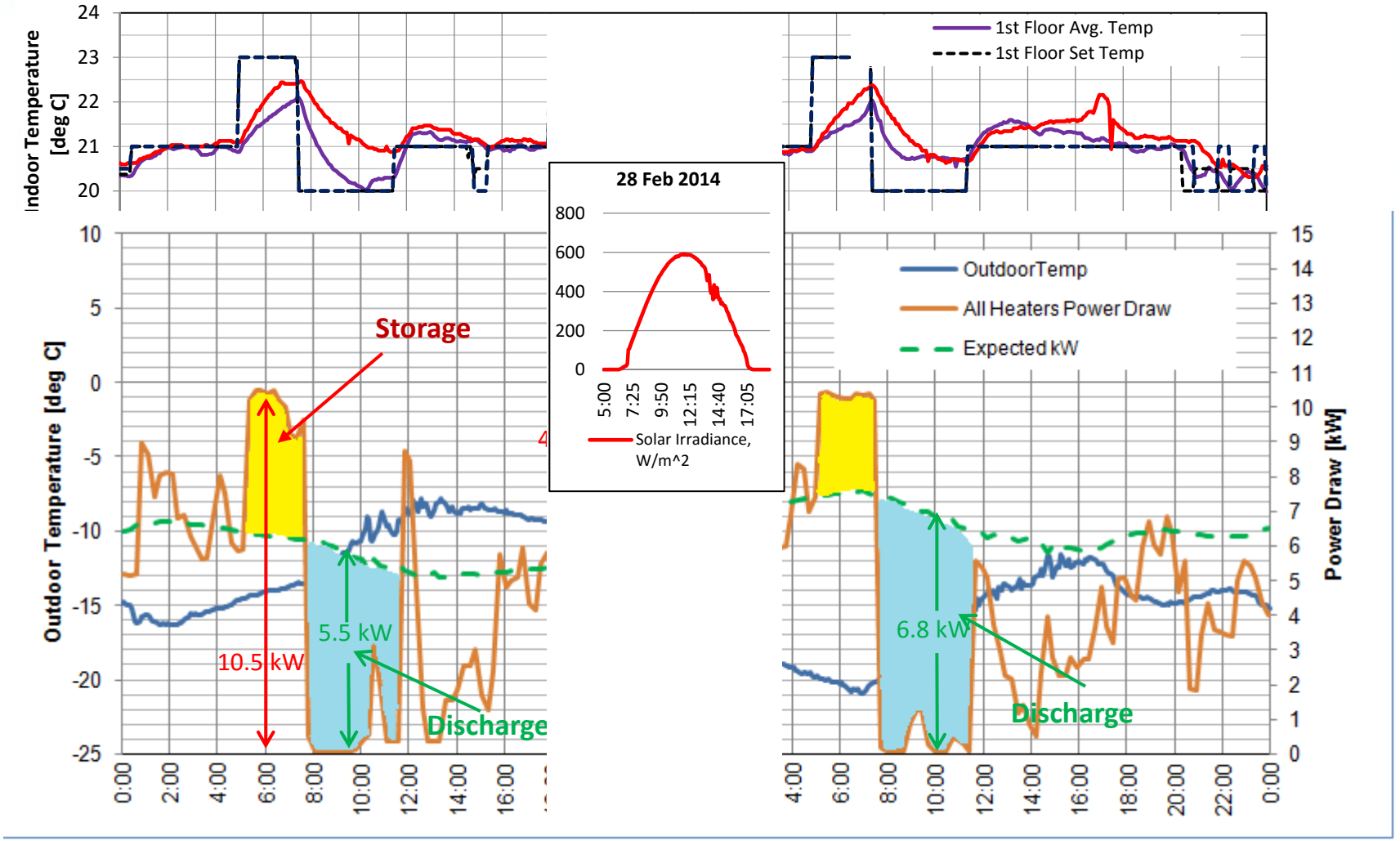
Storage/Discharge & Power Shift



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Canadian Centre for Housing Technology

- Twin-house research facility
- Whole-house performance of energy efficient technologies
- Side-by-side comparisons
- 300+ temperature sensors
- Electric baseboard heaters
- Electric, gas, water meters
- Simulated Occupancy
  - Sensible heat loads
  - Appliances & lighting
  - 60+ events per day

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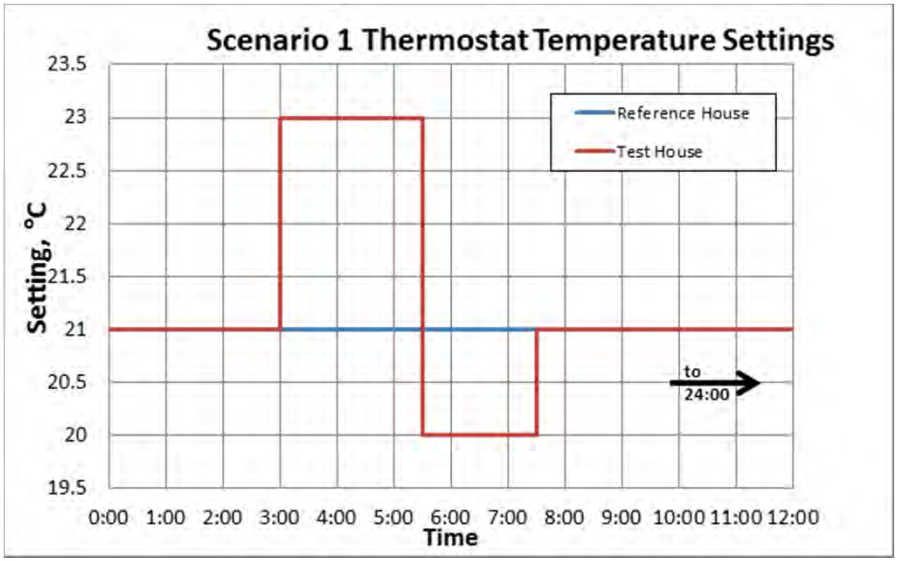
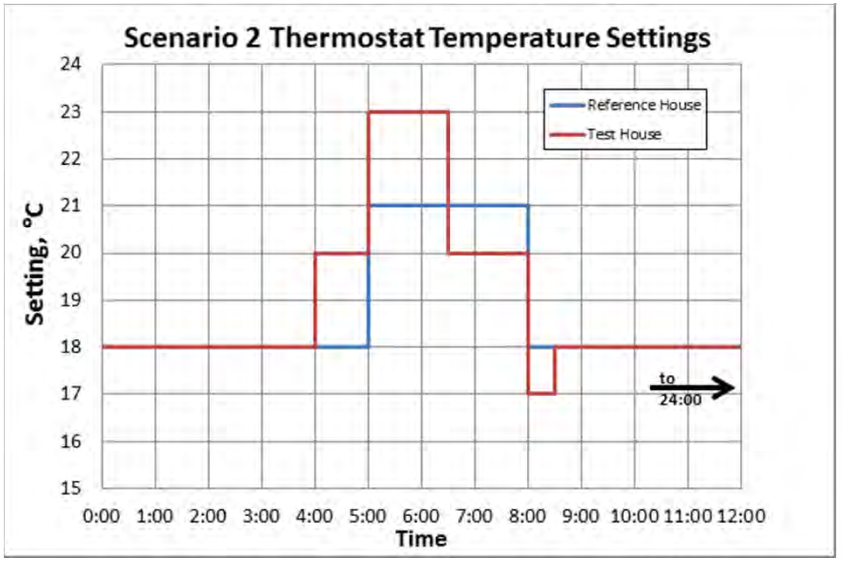
Storage/Discharge Strategies

- Applied to two common types of thermostat programs
- Discharge cycle happens during the critical peak period



Scenario 1: Temp offsets are applied over the constant setpoint of 21 C



Scenario 2: Temp offsets are applied over the setbacks

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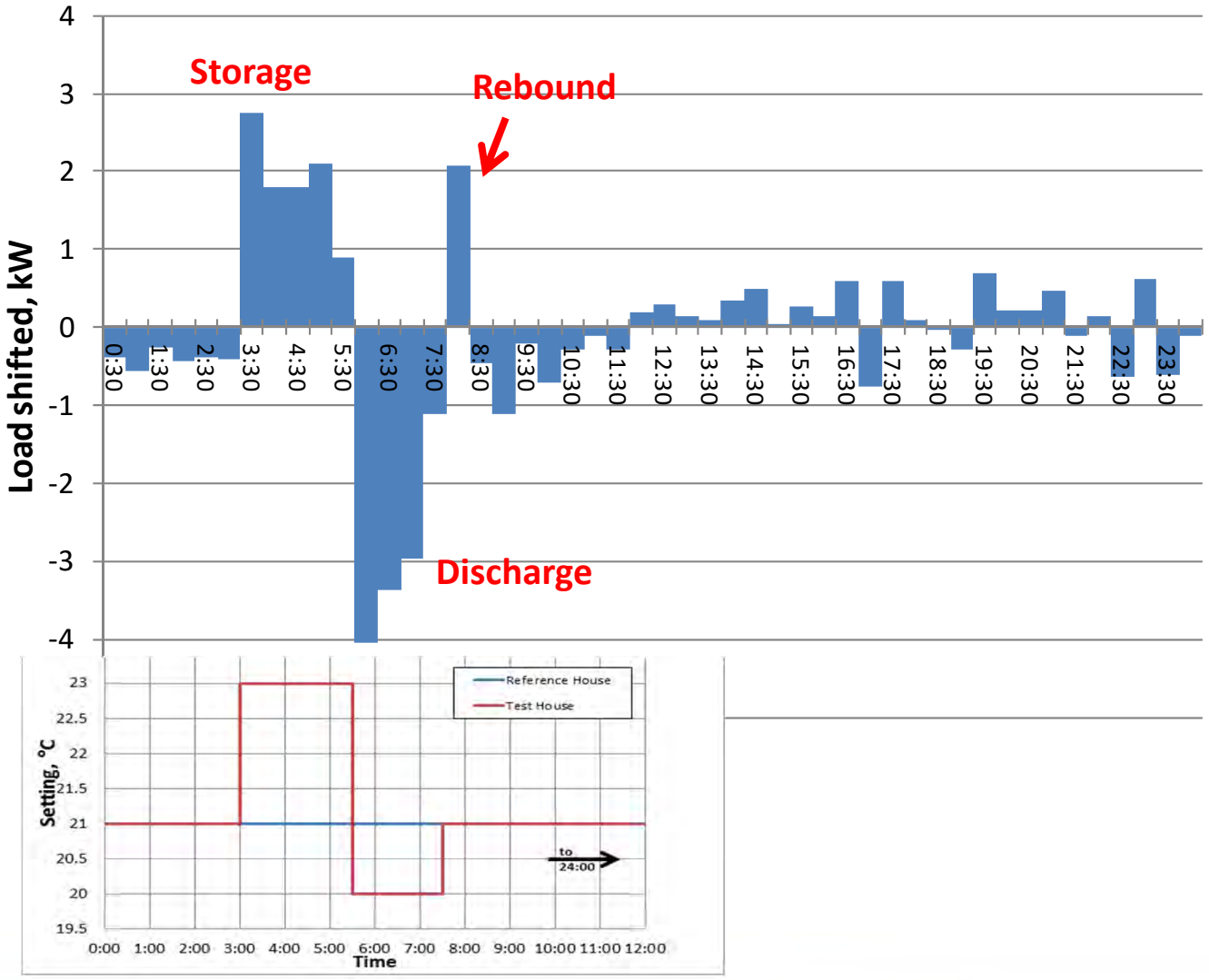
Storage/Discharge & Power Shift



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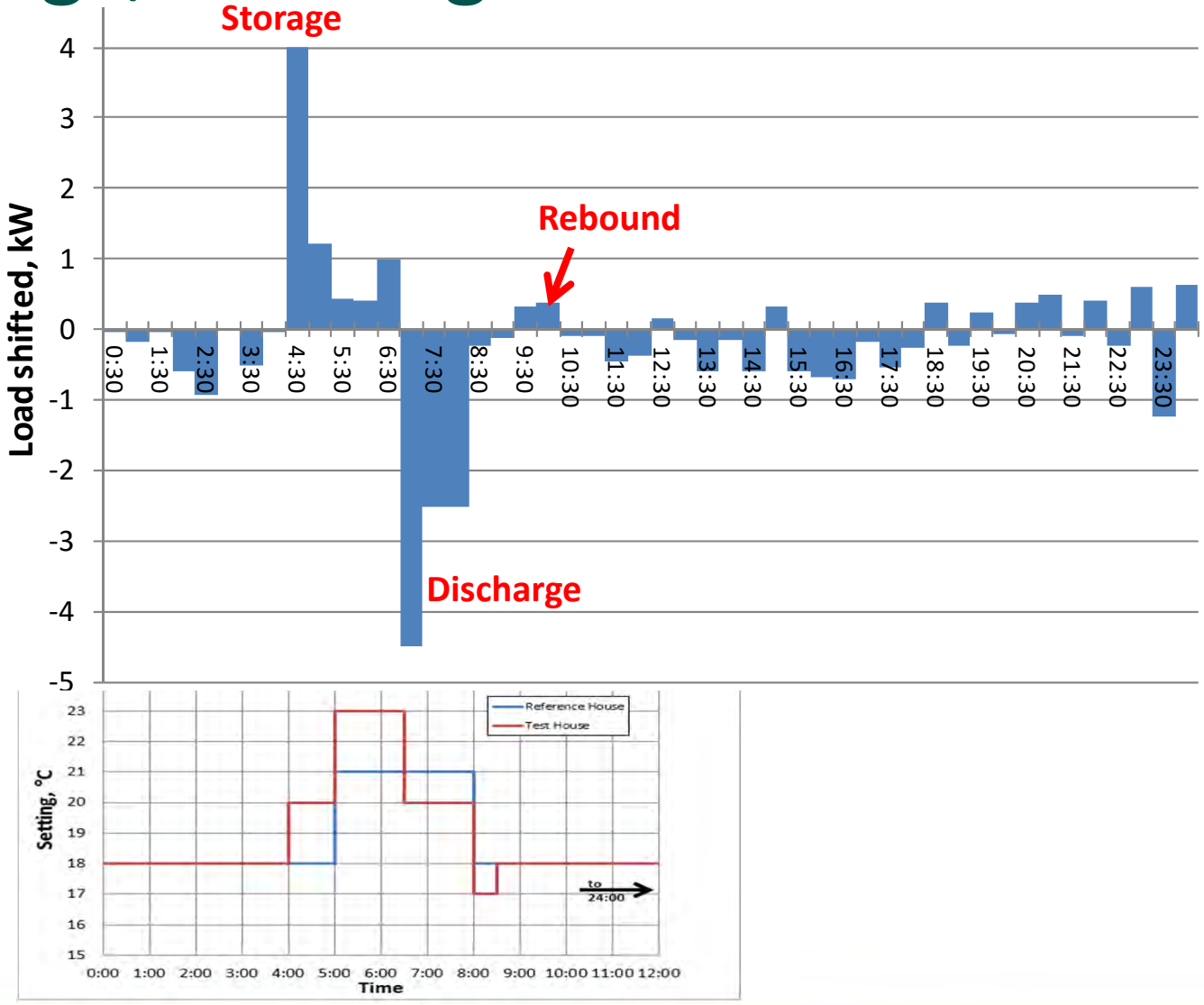
Storage/Discharge & Power Shift



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New Brunswick Pilot, 50 Occupied Homes

- 25 homes are control; 25 homes are experimental
  - 6 interventions applied then groups were swapped
- Reduction of Peak Power (kW)
- Shift in Energy (kWh)
- Occupant comfort
- Acceptability of the technology solution
- Inform business case for the next phase of the project

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New Brunswick Pilot, 50 Occupied Homes

Group	Vintage			No. of Building	Average Controllable Capacity (watts)	Average Total Capacity (watts)
	1946-1983	1984-2000	2001 or later			
A	7	9	9	25	7,540	14,994
B	7	9	9	25	7,720	14,954
Diff.	0.0%	0.0%	0.0%	0.0%	2.4%	0.3%

Group	Average Total Heated Area (sq. ft.)	Average Heated Floor Area (sq. ft.)	Building Type		
			2-Storey	Single Storey	Mini-home
A	1,975.52	1,288.76	8	15	2
B	2,010.72	1,276.8	7	15	3
Diff.	0.0%	0.9%	13%	0%	33%

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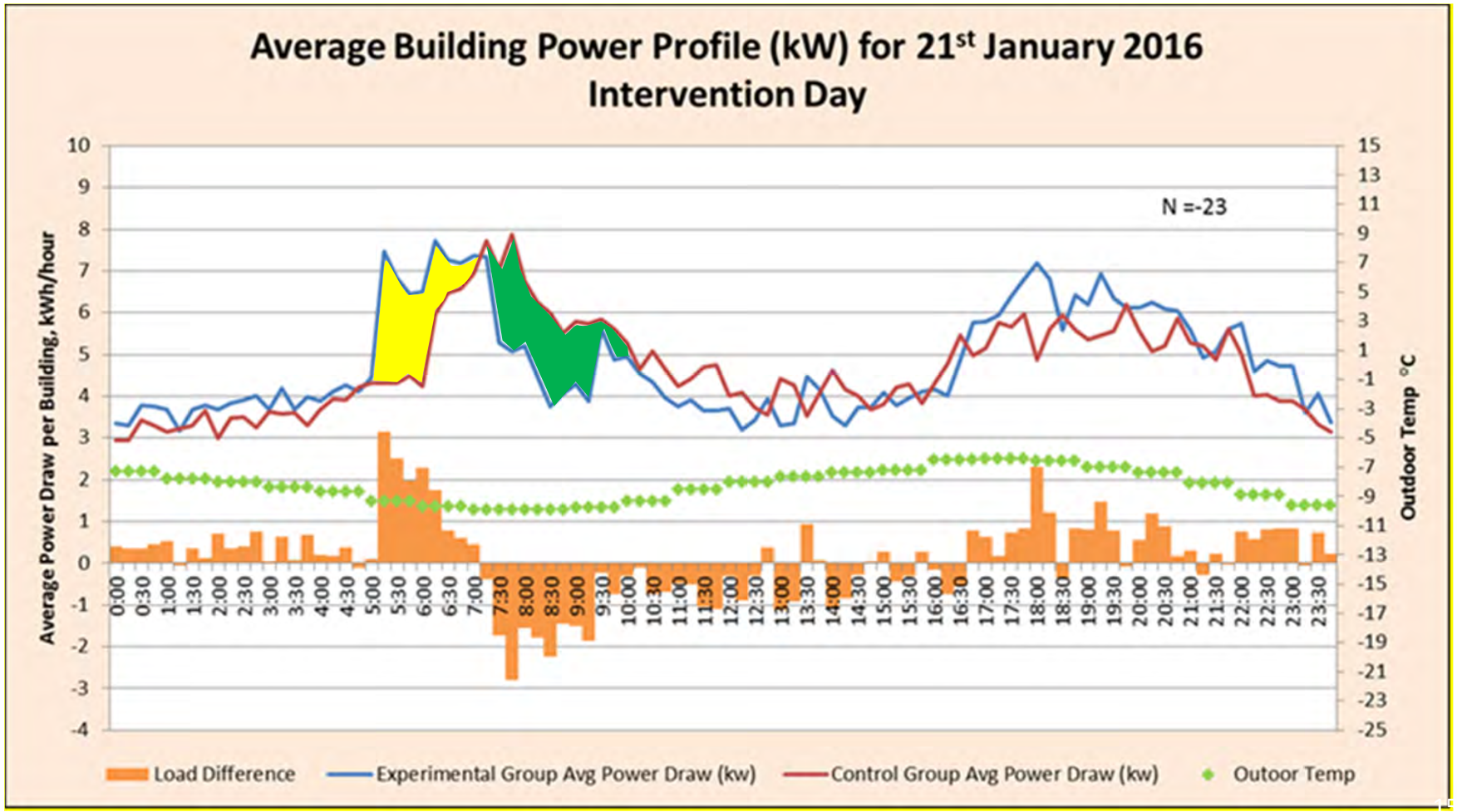
Average Household Load Profile



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50 Occupied Homes Preliminary Findings

- Recruiting 50 homes takes substantial effort
- No complaints of thermal discomfort
- Measured shift for individual homes varied significantly
  - No shift at all → as much as lab
  - Many factors at play
- Aggregated shift of occupied homes can be optimised
  - Time-align shift signatures – optimise DR profile

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Comparison of Sample Results

Typical Single Day Results	First 30 Minutes Shift (% of controllable load)		Total Shift (% of controllable load)		Rebound Peak (% of controllable load)	Energy Penalty (% of 24 hr total)
	Storage	Discharge	Storage	Discharge		
Lab - IARL 10.5 kW controllable 10.5 kW total load	35%	29%	36% for 2.5 hrs	39% for 2 hrs	30%	Not measured
Lab – CCHT 8.0 kW controllable 12.0 kW total load	34%	50%	24% for 2.5 hrs	36% for 2 hrs	29%	~0%
Field - Fredericton* 7.5 kW controllable 15.0 kW total load	37%	31%	20% for 2.25 hrs	25% for 2 hrs	nil	~3%

* Preliminary results, one day of intervention based on A to B comparison

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Lessons Learned

- Technology is Evolving – (Standards, Communications)
- Recruitment
  - Limited Knowledge Behind the Meter
  - Value Proposition
  - Commitment Level
- Measurement & Verification
  - Data from Smart Thermostat (via Vendor Cloud)
  - Data from Home Monitoring Equipment (ERT Meter Read + CT's on Heating Circuits)
  - Very Significant Load Shift and Duration

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Next Steps (currently under consideration)

- Larger Pilot – Winter 16/17
  - Approx. 600 Homes (3000 Thermostats)
  - Hybrid Model of Recruitment
    - Direct Install + Bring Your Own Device (via Retail)
  - Desire for Multiple Vendors
  - Desire to Bundle with AMI (where possible)

Thank You