Demand response in Quebec's CI buildings: potential and strategies

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Hydro Québec

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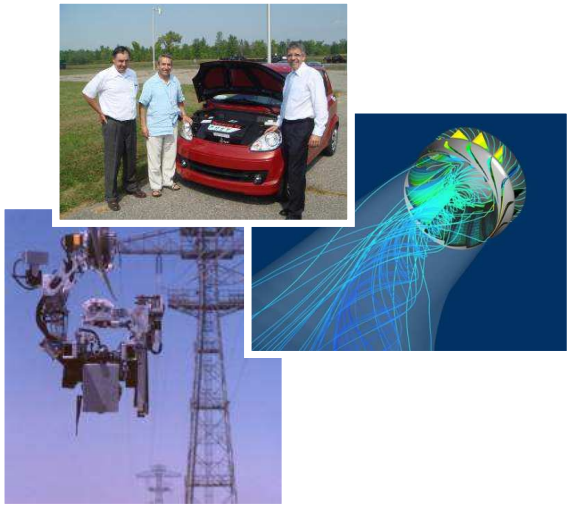
Hydro-Québec's Research Institute

> **2 sites**
- IREQ
- Laboratoire des Technologies de l'énergie

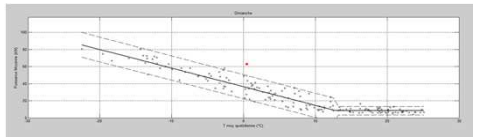
> **500 employees**
- 260 scientifics
- 120 technicians

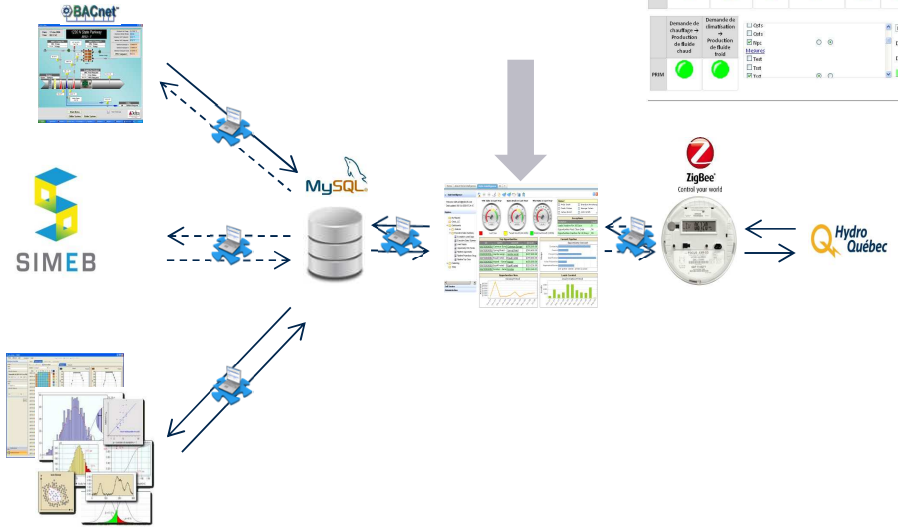
> **Seven fields of expertise**
- Electrical equipments
- Material science
- Robotics and civil works
- Mechanics, metallurgy and hydro-wind
- Measuring and information systems
- Electric networks and mathematics
- Utilization of energy



Project : SGE Building Software

- Increase EE in CI buildings
- Optimze HVAC systems (both energy and peak management)
- Help building operators (fault detection)





at ICEBO 2013…

Calibration of an EnergyPlus building energy model
Lavigne, Karine;
Sansregret, Simon;
Daoud, Ahmed
LTE, Hydro-Québec

SGE Building Software
Nouanegue, Hervé Frank
Daoud, Ahmed
LTE, Hydro-Québec

Demand response in CI buildings

What is DR? why use it ?

Demand response *according to FERC[2]:*

Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized

Winter 2012-2013

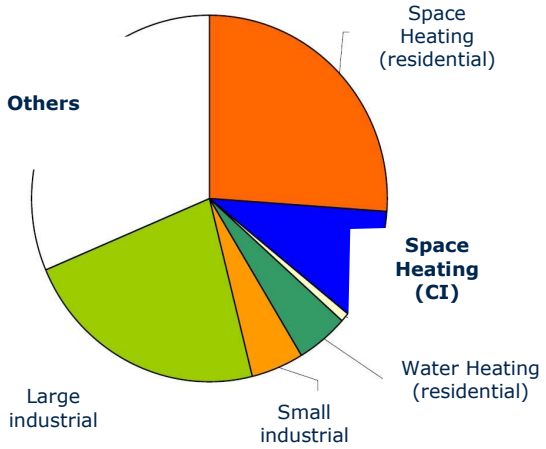
Three historical peaks
Jan 23rd am/pm,
Jan 24th am

~ 39 000 MW

[2] www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp

Why call upon CI customers ?

- more kW/meter
- some all-electric (common in Qc)
- more control capabilities (BAS)
- centralized management
- corporate image



DR Strategies

HVAC												Lighti ng					Other		
Global temp. adjustment	Duct stati c pres. decrease	SAT decrease	Fan VFD limit	RTU Shut off	Duty Cycling RTUs	Pre-heati ng	Fan-coil unit off	Cycle electric heaters	Cycle AHU Fans	Cycle VAVs	Set up CO2 Setpoints	Common area light dim	Offi ce area light dim	Turn off light	Dimmable ballast	Bi-level switching	Non-criti cal process shed	Elevator cycling	Slow Recovery

[3] Kiliccote, S. et *al*, 2009, *Northwest Open Automated Demand Response Technology Demonstration Project*, Environmental Energy Technologies Division, LBNL, avril 2009

Previous work

Demand profiles caracterisation and DR potential

> Study *real demand profiles* per activity sector for caracterisation

> Estimate theoretical DR potential per activity sector

HVAC based DR strategies

> Use building simulation to evaluate DR strategies and study possible ways of optimizing preset systems setpoint profiles

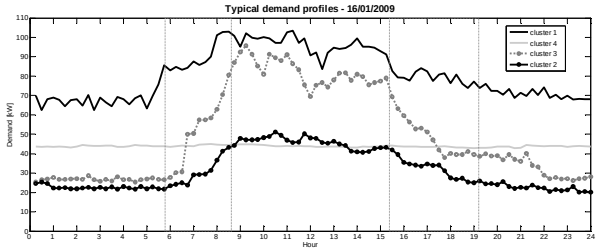
Demand profiles caracterisation and DR potential - *Samples*

Activity sector	Clean sample size (*N*)
Arena	35
Library	12
Office	27
Healthcare*	8
Cinema	20
Retail	132
Small convenience	337
Groceries store	200
University	80
School	**1944**

*long term care facility

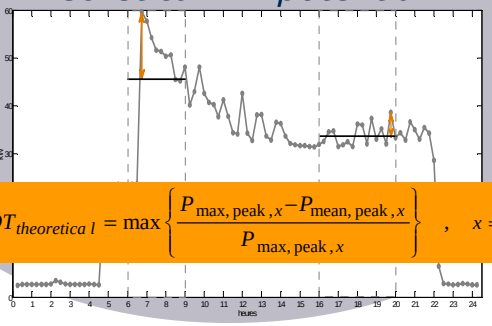
Demand profiles caracterisation and DR potential - *Methodology*

Clustering of samples



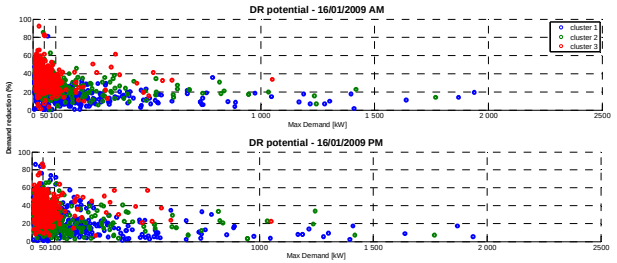
Market data

Theoretical DR potential



$$DR\_POT_{theoretical} = \max\left\{\frac{P_{\max,\,peak,\,x} - P_{mean,\,peak,\,x}}{P_{\max,\,peak,\,x}}\right\}, \quad x = [am,\ pm]$$

DR potential



DR potential

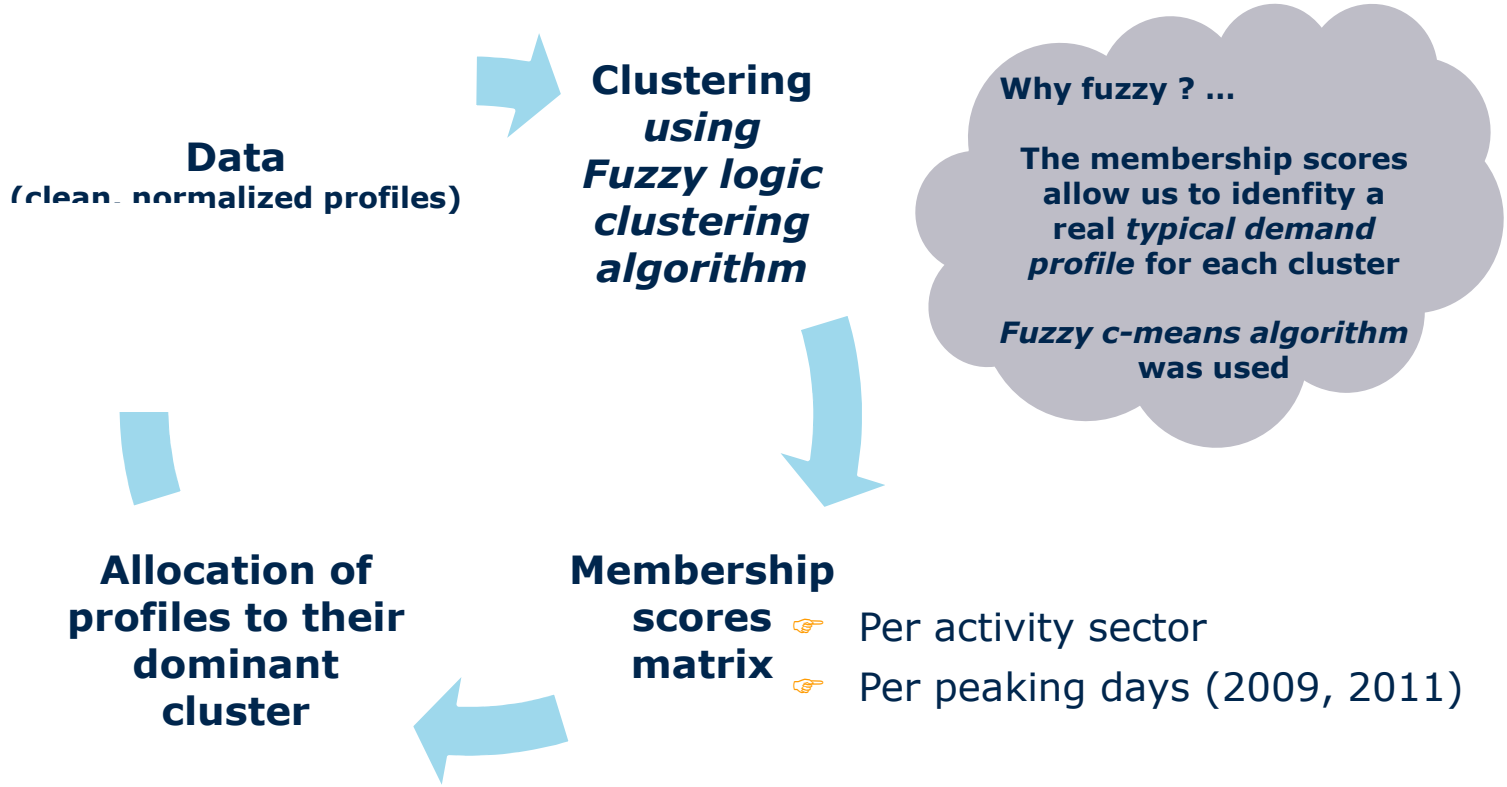
Date		DR potential		
		< 50 kW	50-100 kW	100-5000 kW
2009-01-16	AM	28 % (7 kW/bldg)	21 % (14 kW/bldg)	16 % (42 kW/bldg)
	PM	28 % (6 kW/bldg)	22 % (12 kW/bldg)	17 % (37 kW/bldg)

Other methods

[4] Goldman, C. et *al.*, *A methodology for estimating large-customer demand response market potentiel*, LBL, August 2007

[5] Brattle, *A national assessment of demand response potential*, by The Brattle Group for FERC, June 2009

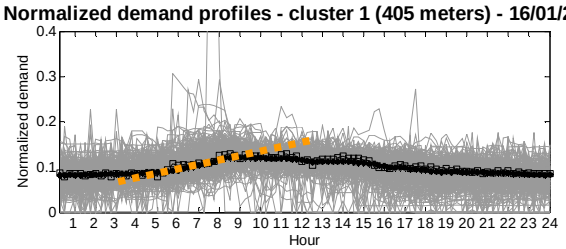
Demand profiles caracterisation - *Clustering*

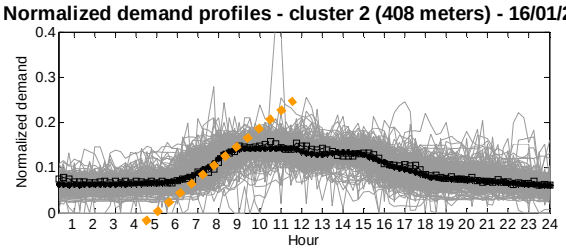


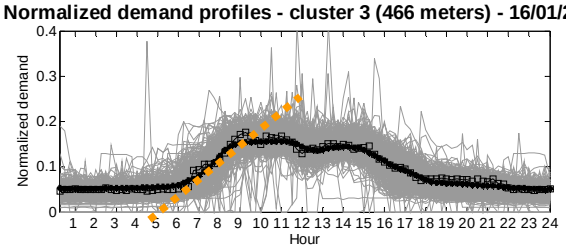
Clustering of electric demand profiles….

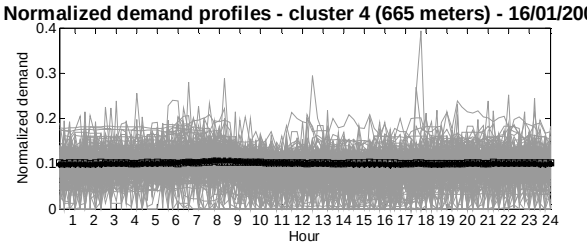
[6] Yamaguchi, N. et *al*. *Regression Models for Demand Reduction based on Cluster Analysis of Load Profiles*, presented at IEEE-PES/IAS Conference on Sustainable Alternative Energy, Spain, Sept 2009
[7] Valero, S. et *al*. *Methods for customer and demand response policies selection in new electricty markets*, IET Gener. Transm. Distrib., Vol. 1, No. 1, Jan 2007
[8] Chicco, G. et *al*., *Comparisons Among Clustering Techniques for Electricity Customer Classification*, IEEE Transactions on Power Systems, vol 21, no 2, may 2006

Demand profiles caracterisation - *Clustering*









SCHOOL

Overall shape?

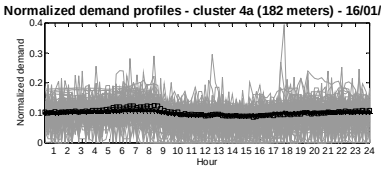
Coincidence with grid peak?

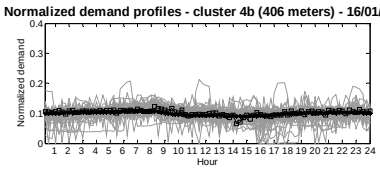
In the future…

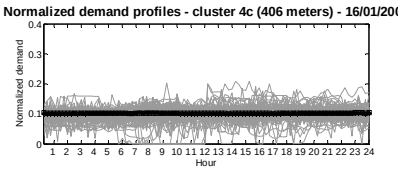
Sub-sampling based on weather sensitivity[9]

Further cleaning of samples

Increase sample sizes

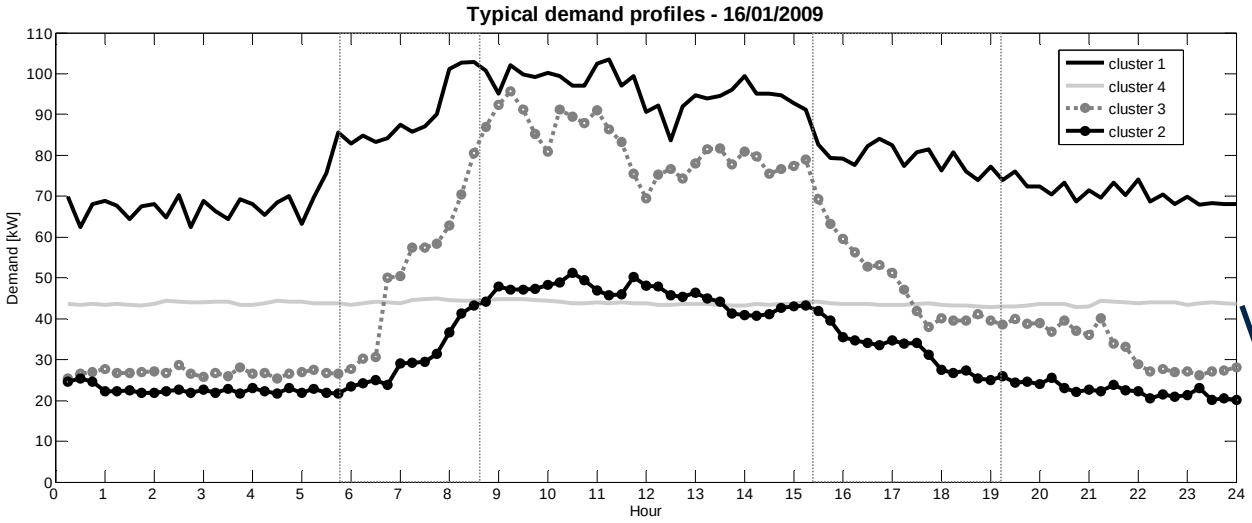






[9] Coughlin, K. et *al*. *Statistical analysis of baseline load models for non-residential buildings*, Energy and buildings, 41, 2009

Demand profiles caracterisation – *Typical demand profiles*



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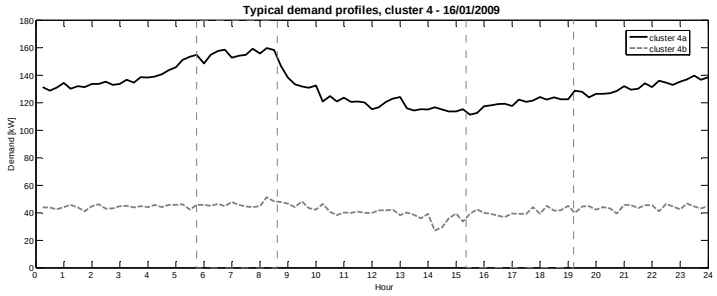
Typical demand profiles used to simulate typical buildings and estimate

- **Impacts on customers (comfort / financial)**
- **Demand reductions of strategies during peaking hours**



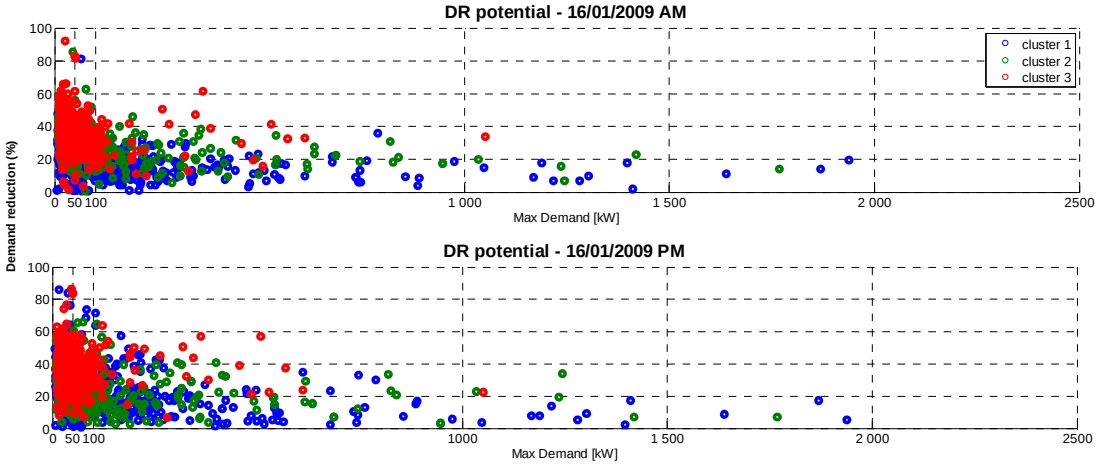
Theoretical DR potential - *example*

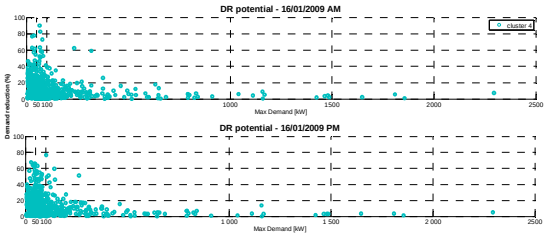
Per Customer size

Date		DR potential		
		< 50 kW	50-100 kW	100-5000 kW
2009-01-16	AM	28 % (7 kW/bldg)	21 % (14 kW/bldg)	16 % (42 kW/bldg)
	PM	28 % (6 kW/bldg)	22 % (12 kW/bldg)	17 % (37 kW/bldg)

Per Cluster

Date		DR potential			
		1	2	3	4
2009-01-16	AM	18 % (26 kW/bldg)	28 % (25 kW/bldg)	38 % (18 kW/bldg)	12 % (11 kW/bldg)
	PM	21 % (24 kW/bldg)	25 % (20 kW/bldg)	37 % (15 kW/bldg)	14 % (11 kW/bldg)





Theoretical DR potential

+….

- Simple
- Applicable to large data samples
- Mean DR_POT can be calculated for customer sizes and clusters
- Independant of specific strategy since systems are unknown

-….

- Accounting only for variations of demand during strictly defined peaking hours
- Conservative (?)
- *4 days analysis…Mean relative DR_POT vary slightly but major differences are mainly associated with varying opening hours for certain activity sectors*

In the future….

Influence of different weekday selection, extending peak hours, +/- variation…

Overall…

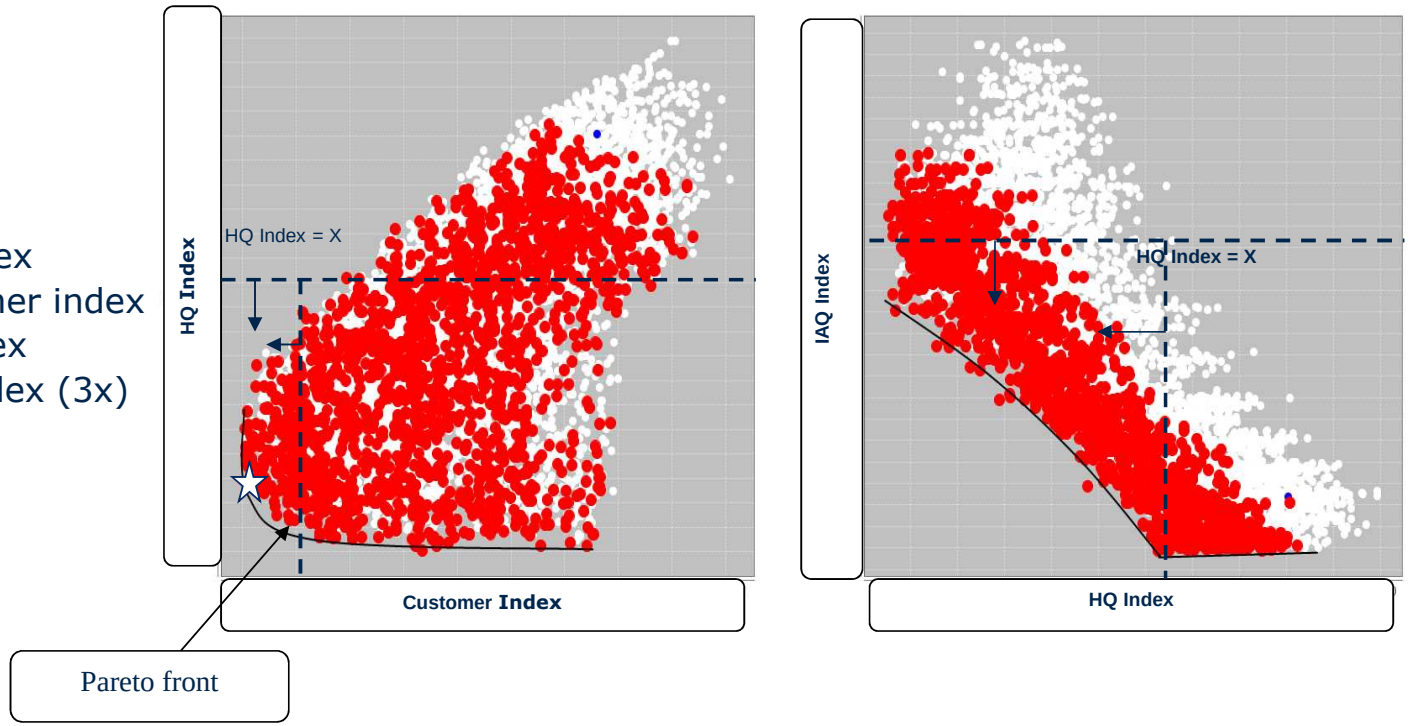
- **good caracterization of customer**
- **valid first estimation of DR potential**
- **better targeting for DR participants**

HVAC based DR strategies

Multi-objectives genetic algorithm (JEPlus 1.4)

- **6 objective functions**
- **13 variables**
- **4 000 simulations**

- HQ index
- Customer index
- T_{air} index
- IAQ index (3x)



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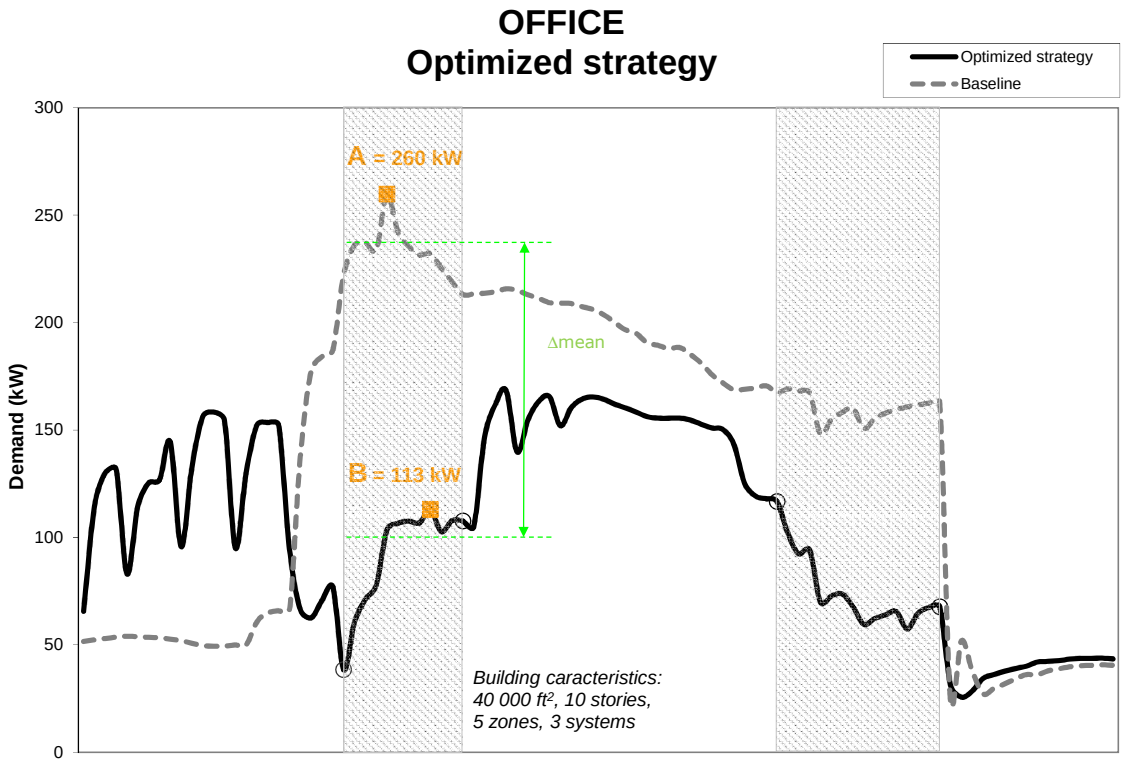
HVAC based DR strategies



- Global temperature adjustment
- Systemic adjustment to air distribution and heating systems

Incudes:
Preheating, preventilating, ZAT adjustment, boiler temperature adjustment, OA shut off

$DR\_POT_{theoretical}$ = **27 kW** **versus** DR_POT_{max} = **147 kW**

DR_POT_{mean} = **140 kW**

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Ongoing work

> Aims

- Improve our estimation of the theoretical DR potential for the most interesting activity sectors and those not already covered
- Verify the feasability of HVAC DR strategies in real buildings through a demonstration project
- Study baseline calculation methods

Demonstration Project

Objective

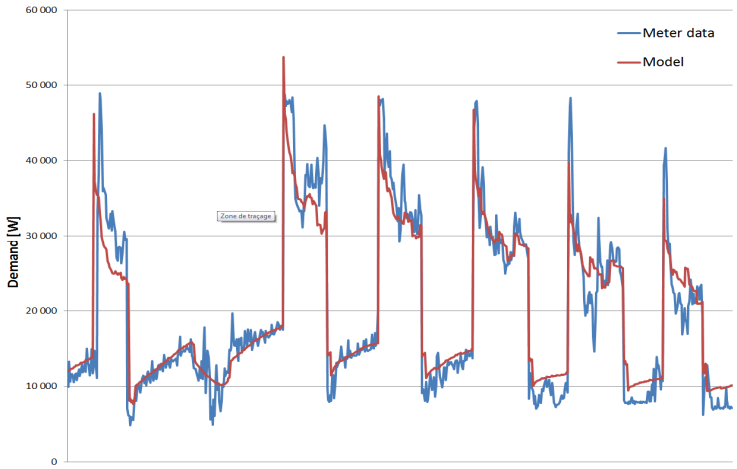
Verify the feasability of DR strategies in real buildings through a multi-buildings, multi-systems demonstration project

	Surface area [ft²]	Max demand [kW]	HVAC systems to be controlled			
			Central	RTU	Base board	Unit heater
School	26 800	190	x	x	x	x
Retail	22 500	190		x		x
Bank	4 600	50		x	x	
Retail	12 900	200	x	x	x	x
Office	21 000	n/a	x	x	x	

* *All-electric buildings*

Demonstration Project - *Methodology*

- *Recruitment*
- *Technical survey of facility*
- *Simulation/calibration of a baseline model*
- *Simulation/optimisation of DR strategies*



- *Implementation of DR strategies in BAS*
- *Four DR events during peaking season*
  - prescheduled events or 24h notice, **semi-AUTO DR**
- *Demand reduction evaluation*

HVAC based DR strategies

- *RTUs cycling*
- *ZAT setpoints adjustments with preheating*
- *CO_2 setpoints adjustments with overventilating*
- *OA limiting*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