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Demand Side Management with Line Voltage Communicating Thermostats: a Real Life Experiment

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Hydro-Québec

- Government owned utility with generation, transmission and distribution activities
  - 37 GW of generation capacity
  - 202 TWh of sales
  - 4.2M customers
- 99% of our generation is from hydropower
- Among lowest residential tariff in North America
  - Large share of electric heating
- Winter peaking
  - in January and February, when temperature drops below -20°C (4F)
  - between 6-9 AM and 4-8 PM
  - at about 39 GW (2014)

LVCT pilot project

Context

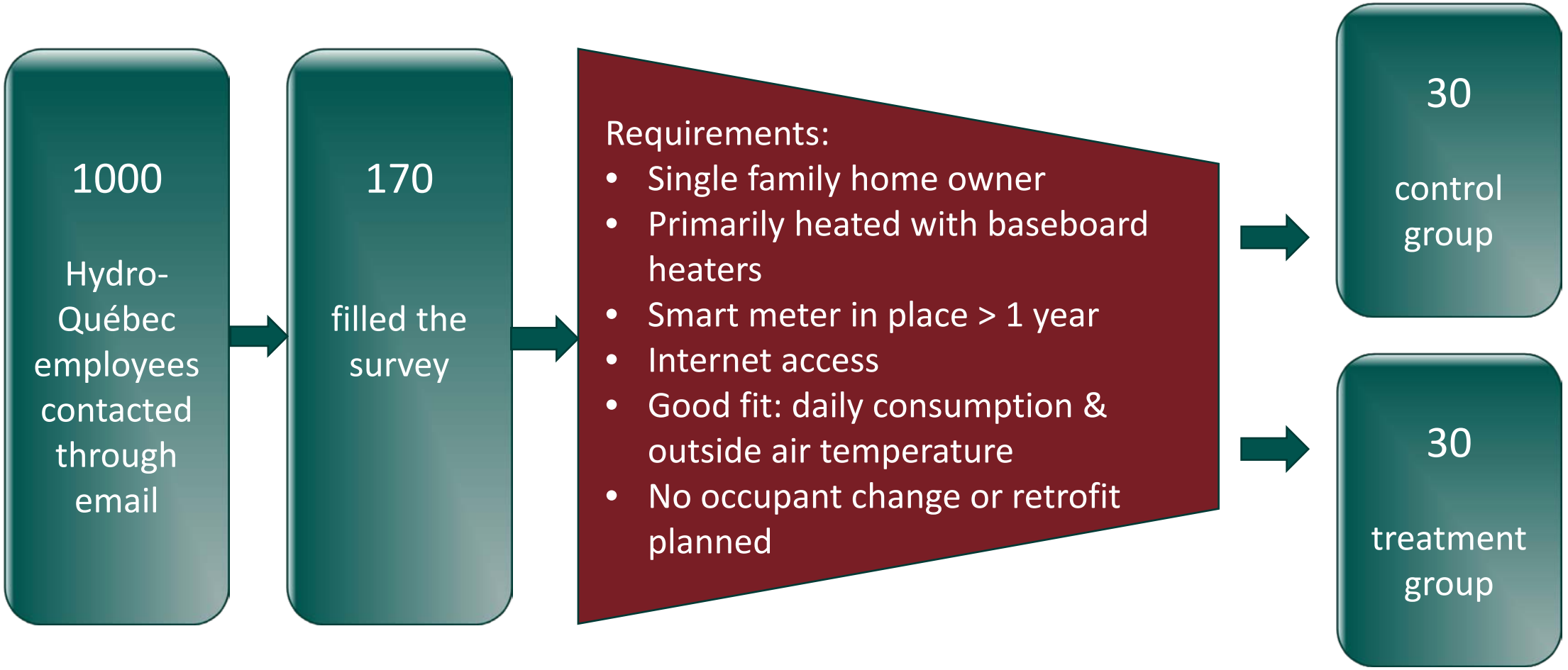
- Most of our customers use baseboard heaters as their main heating system
  - Require line-voltage thermostats (240V)
- Line-voltage communicating thermostats (LVCTs) hit the market in 2015
  - Provide feedback on heating costs on a room per room basis
  - Allow peak shaving through remote setpoint modulation*

Objectives

- Assess performances of LVCT in real conditions
  - Energy savings
  - Peak shaving
- Probe customers interest for DR using this technology
  - comfort level, satisfaction and drivers for participation

* We already had a laboratory testing phase http://aceee.org/files/proceedings/2016/data/papers/1_88.pdf

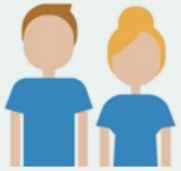
Recruitment



Portrait of participants* – the facts

Household members

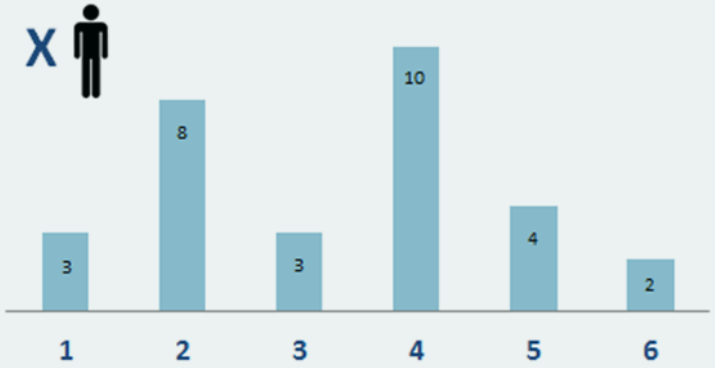
70% with at least one child or teenager



20% couples and adults only

10% single

Household size



63% have at least one pet

Before 1970
33%

Wall mounted heat pump
27%

26 280 kWh/yr

Images: www.hydroquebec.com and www.freepik.com

* Treatment sample

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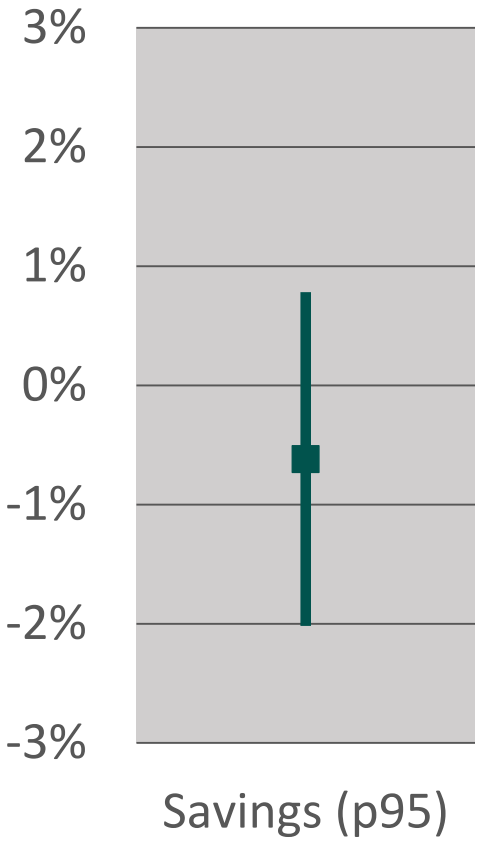
Installed equipment

- Each and every LV wall thermostat replaced with a Sinope Technology LVCT
  - Average of 10 per house
- Gateway to link the wireless network of thermostats to the cloud through the participants' internet connexion
- Web and mobile interface to access settings, view historic consumption and program setpoint schedules

Pilot sequence

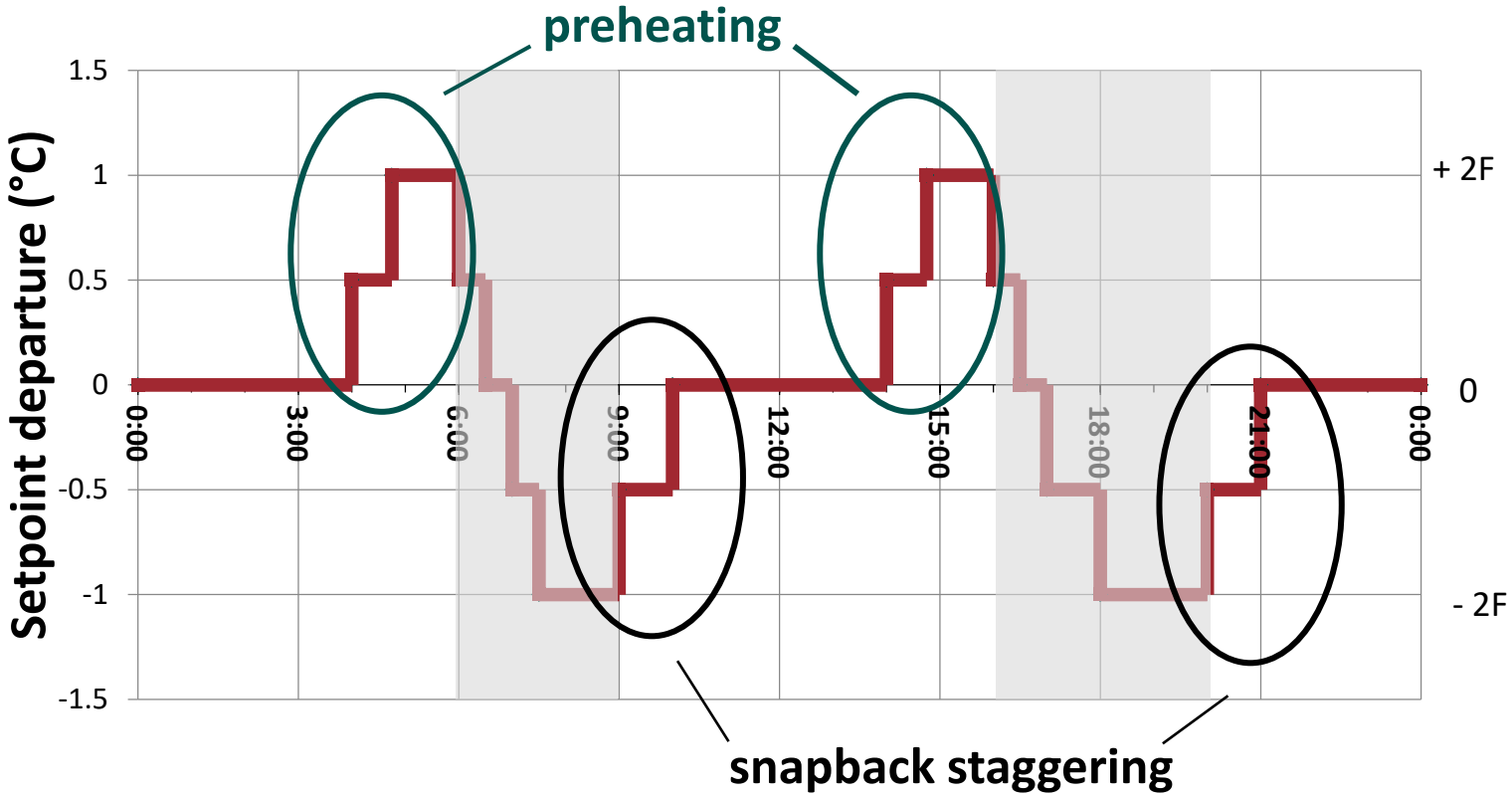
November and December 2016	January to March 2017	End of March 2017
• Equipment installation • Break-in DR day	• 8 DR days (2 events/day) • Comfort survey after each event • AMI data at 15 min intervals for DR impacts and energy savings valuation at whole house level	• Survey on overall satisfaction with DR experience

Energy savings



- No statistically significant change in energy consumption between winter 2016 and winter 2017 for control and treatment groups using autocorrelated daily consumption regressions
- No savings could be attributed to the LVCT

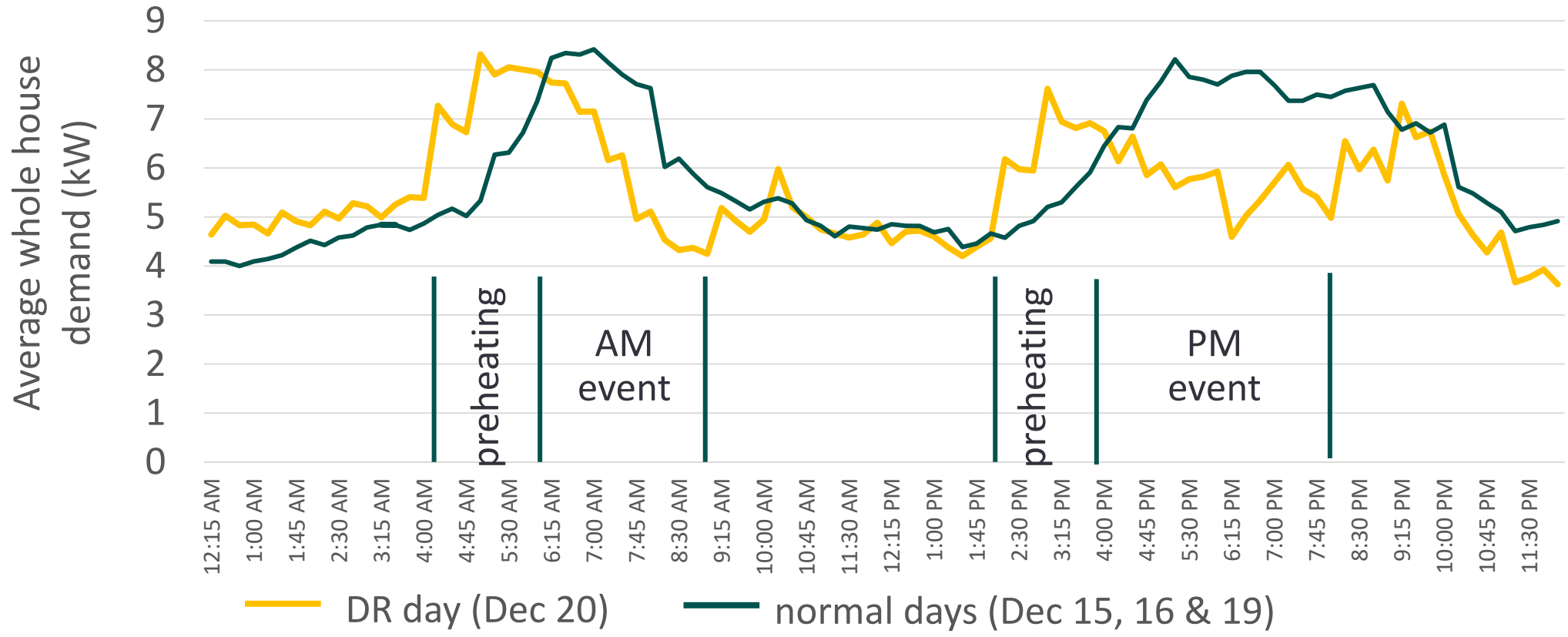
Setpoint modulation strategies



- Around regular setpoint schedule
- 2 options
  - All thermostats
    - +1/-1°C (2F)
  - 4 thermostats (not shown)
    - +2/-1°C (+3.6/-2F)

- Participants notified by email in the afternoon for the next day
- Always free to change their setpoints

DR results, aggregated load profiles



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DR results, load shed

- 8 DR days
  - Events where outside temperature ≥ -5°C (23F) were removed
  - Remaining events average temperature, AM: -15 °C (5F), PM: -10 °C (14F)

Nb of controlled thermostats	all (10 on average)	4
Setpoint modulation	+1/-1°C (2F)	+2/-1°C (+3.6/-2F)
Average demand shed 6 to 9 AM and 4 to 8 PM	~ 2 kW	~ 1 kW

- Hourly consumption baseline was estimated with seasonal weather regressions

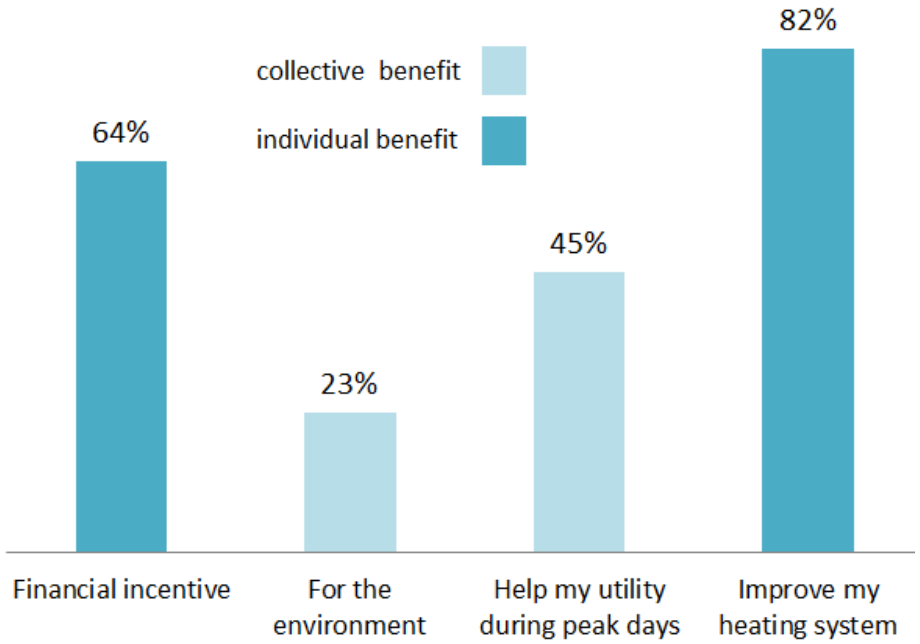
Participants' DR experience - findings

- Post event surveys
  - Participants were generally comfortable*
  - Some discomfort was felt :
    - Cold sensation at the end of the evening events
    - Hot sensation during preheating in the morning events
  - If respondents felt slightly cold/hot, most did nothing or simply modified their clothing
- End of pilot survey
  - +75% were satisfied with the DR strategies
  - 40% said that knowing that an event was ongoing encouraged them to modify their use of other loads (e.g. delay dishwasher use)

*Occupants were asked about their thermal sensation on a seven points scale. Satisfied occupants score: -1, 0, 1 , i.e *slightly cold*, *neutral* or *slightly hot*.

Participation in DR – drivers & barriers

Drivers



- Almost half would participate with a minimal incentive

Key attributes

- Notifications
- Personalization
- Control

Barriers

- Discomfort
- Interferences with existing equipment

Comments from participants

- About 70% of respondents indicated that more aggressive strategies could have been applied in some rooms
- Some respondents indicated that being able to adapt the strategies for each room would represent added value to them

We would have liked to be able to set a lower limit… e.g. do not go below 19°C in some rooms.

Some of the rooms are unoccupied so preheating is not useful. This could be taken into account.

Temperature setpoint could have been lower during the night or when we were away…

Conclusion

- Performances of LVCTs were assessed in real conditions
  - No significant energy savings
  - Significant and sustained (3-4 hours) demand shed with limited control (+1/-1°C) [2F]

- Participants are favorable to DR using this technology
  - Low discomfort, high acceptability
  - Limited incentive required
  - Convenience of remote control is a strong selling point
  - Appeal for DR strategy personalization

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