



Business Case for
Natural Refrigerants

June 12-14, 2018 – Long Beach

To measure is to know

Efficiency is a key to the future

Supermarket performance benchmarking

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Supermarket performance benchmarking and optimization

Culture in supermarket industry - keep it cool – focus on investment – no continuous optimization

Measuring and validation of operating performance has not been part of business

Quick response to restore cooling is important performance indicators for maintenance

Actual performance is unknown - considered impossible to measure in the field

Challenges in benchmarking

- ✓ No stores are identical
- ✓ This week or year is not the same as last - ambient and load changes
- ✓ Stores are hardly ever optimized – saving potential of 20-30% in almost all stores



Supermarket performance benchmarking

Proven field measuring method – 30 years of experience – cloud based since 2009

- Unbiased – science based method works on all type of systems
- Well proven from thousands of inspections and long term monitoring projects
- Proven by manufacturers, test labs, research institutes, **Grocery Retailers - used in utility programs**

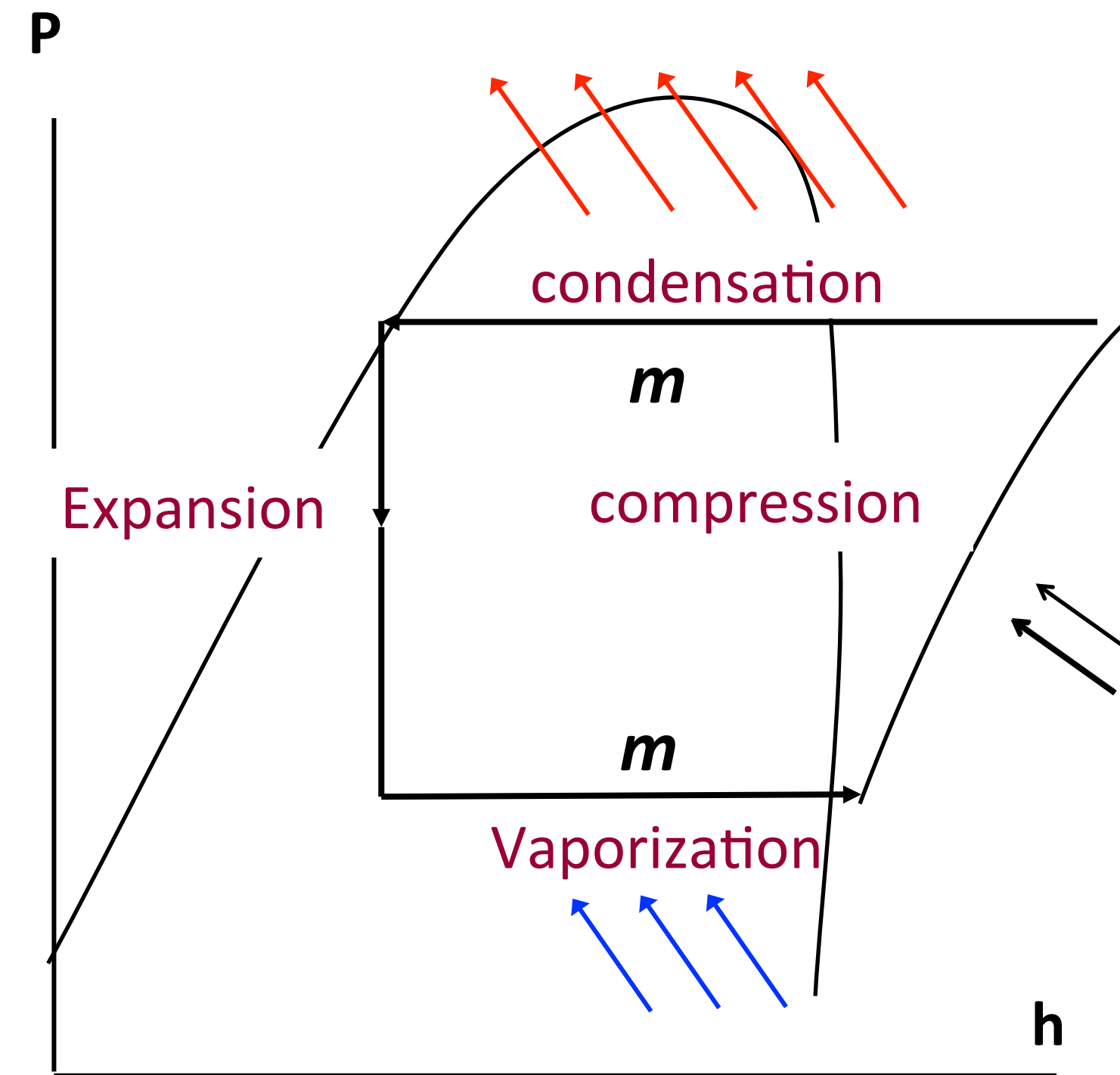
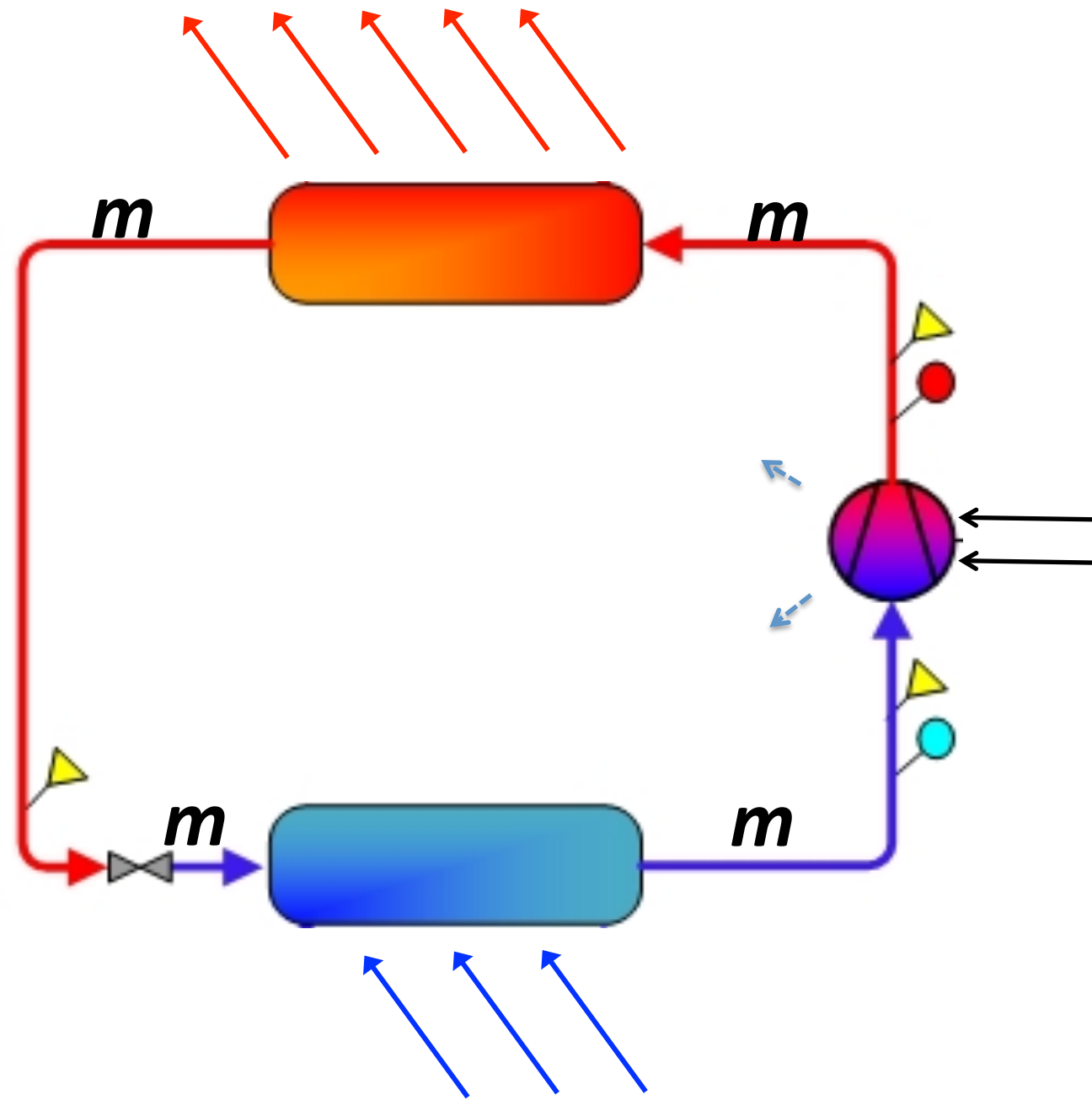
Users include i.e. NREL – BPA - Emerson – Hill Phoenix - New Seasons Markets - EPRI – Sobeys

We are 3 years into a project with BPA, results will be published within short on the NEEA web page

- ✓ 20-30% savings common result of optimization with small or no capital investment
- ✓ Challenge is “business as usual” – service sector do what they are requested to do
- ✓ Service sector has no incentive and rarely have tools or experience to optimize

Supermarket performance benchmarking

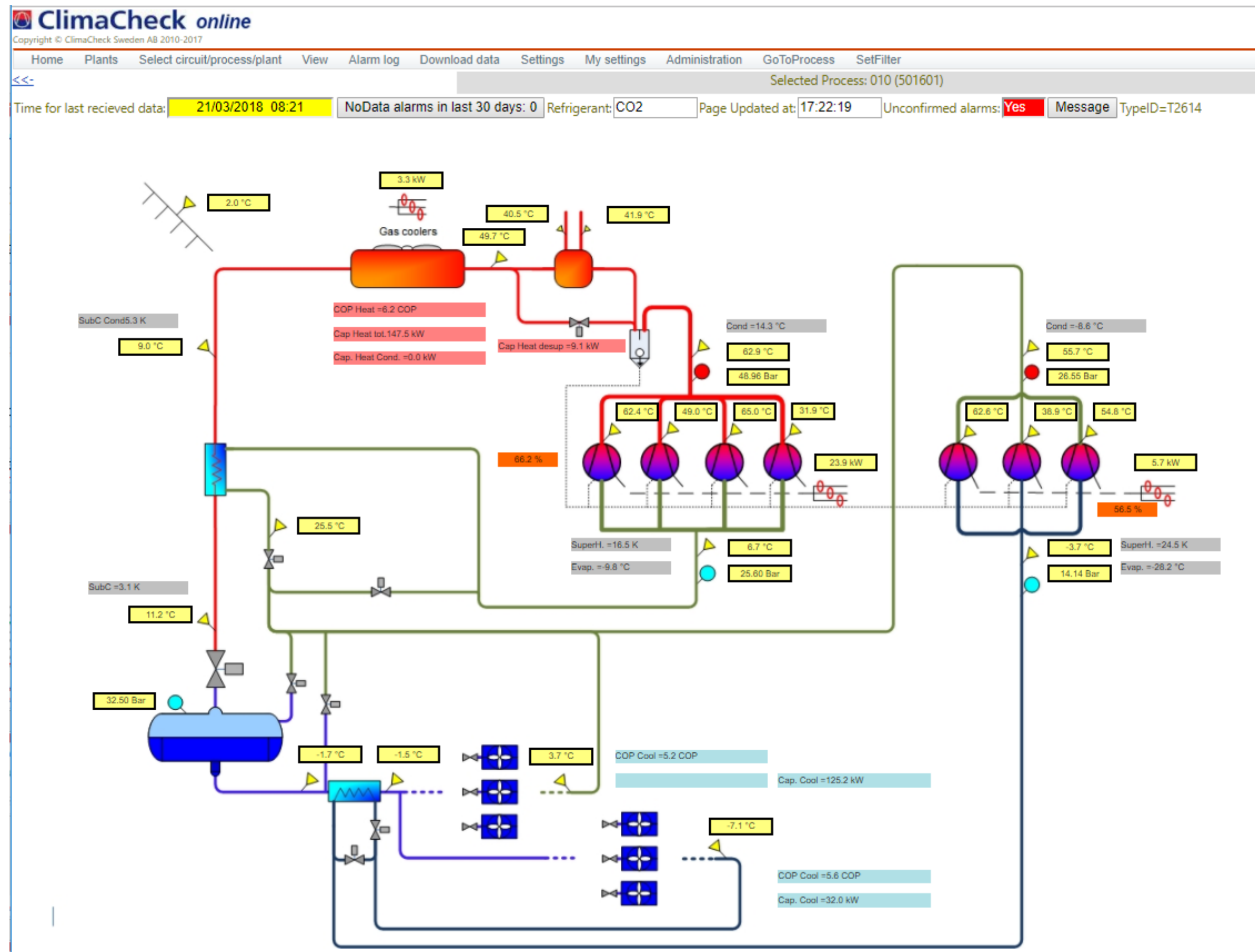
Basic Refrigeration Cycle



Scientifically based on thermodynamics - unbiased – require no manufacturer input

Supermarket performance benchmarking

Method applicable on complex CO2 booster systems and hydrocarbons to optimize and validate performance



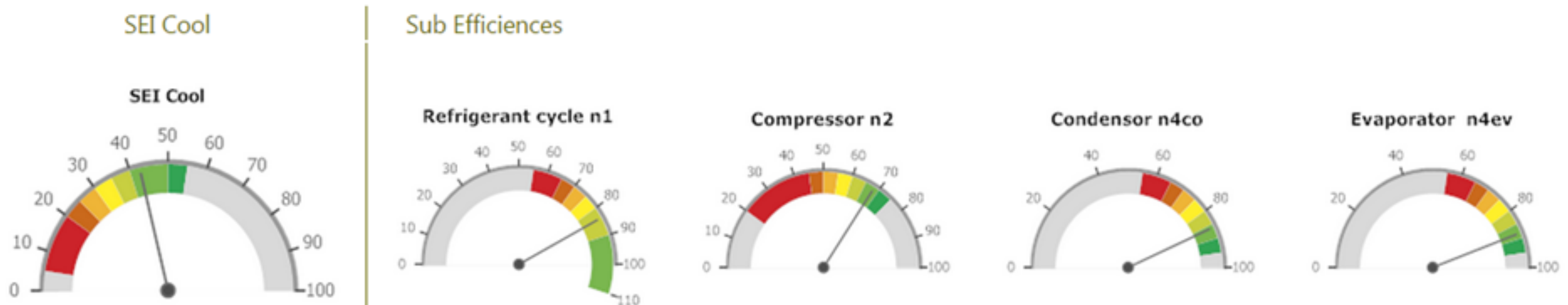
Most sensors are already there

Analytics are based on physical properties of the refrigerant

Cloud based analytics give access to any experts with authorization

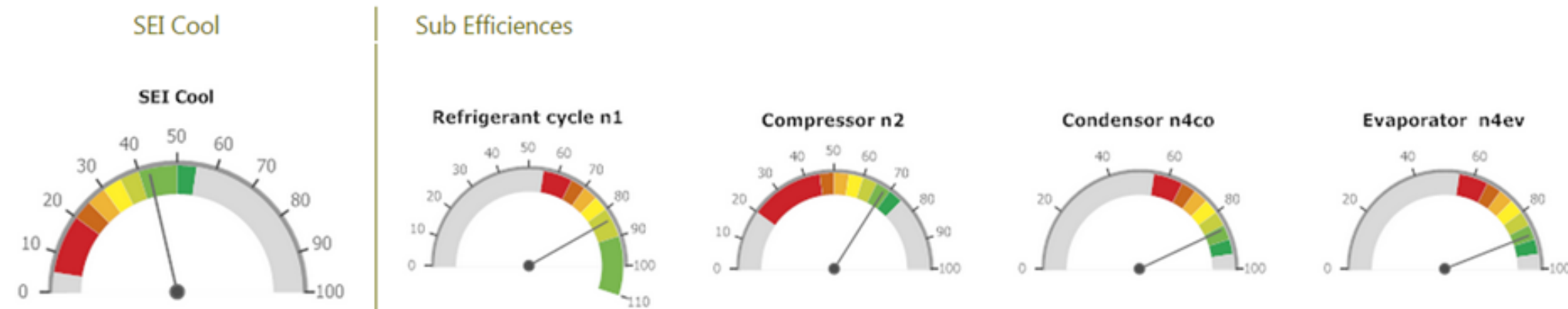
Supermarket performance benchmarking

- » Key Performance Indicators in real time – visualised for none expert
- » System Efficiency Index – how efficient is the system relative a loss free process?
- » Identify the saving potential.
- » Early warning – know when performance decrease - not when system failed



Supermarket performance benchmarking

“All” information available in real time on dash board or test bench level



| Power input Comp. (kW) | Power input SecW (kW) | COP Cool Ref | Cap. Cool (kW) | Cap. Heat (kW) |
|------------------------|-----------------------|--------------|----------------|----------------|
| 37.7 | 4.90 | 5.96 | 221.1 | 255.6 |
| 11.1 | 0.70 | 4.10 | 45.5 | 55.8 |
| 24.2 | 2.57 | 5.10 | 123.7 | 146.2 |
| 27.2 | 3.00 | 5.36 | 145.9 | 171.2 |
| 24.9 | 3.20 | 5.28 | 131.5 | 154.7 |
| 23.6 | 3.30 | 5.25 | 123.9 | 145.8 |

ClimaCheck online
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Home Plants Select circuit/process/plant View Alarm log Download data Settings My settings Administration GoToProcess SetFilter

Selected Process: 010 (501601)

Refrigerant: CO2 Unconfirmed alarms: Yes

Date to show: 21/03/2018 No of values per page: 40 Max-Min-Avg calculated on the last 60 min Time Search: Search

System settings active: 21/03/2018

Export functions: Page to XL All to XL Page to PDF

| Time | Ref Low press. (Bar(g)) | Ref Evap (°C) | Ref Comp in (°C) | Super heat (K) | Outdoor temp (°C) | Ref High press. (Bar(g)) | Ref Cond (°C) | Sub cool cond (K) | Ref Exp. Valve in (°C) | Sub cool total (K) | Ref Comp out (°C) | Power input Comp. (kW) | Power input SecW (kW) | COP Cool Ref | Cap. Cool (kW) | Cap. Heat (kW) | Eff 1 Cycle (%) | Eff 2 Comp. Isen. (%) | Eff 4 Cond. (%) | Eff 4 Evap (%) | Ref Comp1 out (°C) | Eff 2 Comp. 1 (%) | Ref Comp2 out (°C) | Eff 2 Comp. 2 (%) | Ref Comp3 out (°C) | Eff 2 Comp. 3 (%) | Ref Comp4 out (°C) | Eff 2 Comp. 4 (%) | Energy Comp (kWh) | Energy Aux (kWh) | Energy Tot (kWh) | Cap desup heat (kW) |
|---------------------|-------------------------|---------------|------------------|----------------|-------------------|--------------------------|---------------|-------------------|------------------------|--------------------|-------------------|------------------------|-----------------------|--------------|----------------|----------------|-----------------|-----------------------|-----------------|----------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|-------------------|------------------|------------------|---------------------|
| Max last 60 min | 27.96 | -6.8 | 10.4 | 18.9 | 3.0 | 52.18 | 16.9 | 6.7 | 15.8 | 5.8 | 67.6 | 37.7 | 4.90 | 5.96 | 221.1 | 255.6 | 76.15 | 82.3 | 82.13 | 126.22 | 69.3 | 70.6 | 70.9 | 119.3 | 67.4 | 118.9 | 68.7 | 118.7 | 383,917 | 65,237 | 449,154 | 22.1 |
| Min last 60 min | 24.08 | -11.9 | 5.8 | 14.1 | 2.0 | 44.24 | 10.2 | -0.3 | 7.4 | -0.6 | 59.4 | 11.1 | 0.70 | 4.10 | 45.5 | 55.8 | 68.36 | 36.9 | 61.09 | 98.80 | 55.4 | 44.0 | 29.7 | -20.0 | 34.1 | -20.0 | 31.1 | -20.0 | 383,894 | 65,234 | 449,128 | 4.4 |
| Avg last 60 min | 26.15 | -9.1 | 7.3 | 16.4 | 2.1 | 48.63 | 14.0 | 3.8 | 11.1 | 2.9 | 63.5 | 24.1 | 2.54 | 5.11 | 123.0 | 145.4 | 72.76 | 61.5 | 70.33 | 112.22 | 63.2 | 61.9 | 53.7 | 45.2 | 49.2 | 80.6 | 46.1 | 76.4 | 383,905 | 65,236 | 449,141 | 10.8 |
| 2018-03-21 08:23:32 | 25.88 | -9.5 | 6.8 | 16.3 | 2.0 | 48.59 | 14.0 | 5.9 | 9.5 | 4.5 | 62.7 | 24.9 | 3.20 | 5.28 | 131.5 | 154.7 | 74.05 | 63.4 | 70.31 | 109.98 | 61.9 | 65.0 | 45.3 | 100.0 | 64.0 | 61.0 | 31.1 | -20.0 | 383,917 | 65,237 | 449,154 | 9.5 |
| 2018-03-21 08:22:32 | 25.68 | -9.7 | 6.7 | 16.4 | 2.0 | 48.90 | 14.2 | 6.0 | 10.1 | 4.1 | 63.1 | 23.6 | 3.30 | 5.25 | 123.9 | 145.8 | 73.44 | 64.9 | 69.87 | 108.61 | 62.4 | 66.4 | 47.1 | 100.0 | 64.7 | 61.9 | 31.5 | -20.0 | 383,917 | 65,237 | 449,154 | 9.1 |
| 2018-03-21 08:21:32 | 25.60 | -9.8 | 6.7 | 16.5 | 2.0 | 48.96 | 14.3 | 5.3 | 11.2 | 3.1 | 62.9 | 23.9 | 3.30 | 5.24 | 125.2 | 147.5 | 72.43 | 66.2 | 69.87 | 108.06 | 62.4 | 67.2 | 49.0 | 119.3 | 65.0 | 62.2 | 31.9 | -20.0 | 383,917 | 65,237 | 449,153 | 9.1 |
| 2018-03-21 08:20:32 | 25.97 | -9.3 | 6.8 | 16.1 | 2.0 | 49.15 | 14.4 | 3.4 | 13.4 | 1.0 | 62.8 | 24.0 | 3.10 | 5.06 | 121.5 | 143.9 | 70.64 | 64.6 | 68.78 | 110.45 | 62.0 | 66.2 | 51.4 | 101.1 | 64.6 | 61.2 | 32.4 | -20.0 | 383,916 | 65,237 | 449,153 | 9.0 |
| 2018-03-21 08:19:32 | 26.12 | -9.2 | 6.9 | 16.1 | 2.0 | 49.47 | 14.7 | 0.5 | 14.1 | 0.6 | 62.6 | 25.7 | 2.30 | 5.07 | 130.4 | 154.3 | 70.06 | 65.4 | 67.78 | 111.28 | 62.3 | 66.0 | 54.0 | 90.2 | 64.7 | 61.4 | 32.9 | -20.0 | 383,916 | 65,237 | 449,152 | 9.9 |
| 2018-03-21 08:18:32 | 25.93 | -9.4 | 6.4 | 15.8 | 2.0 | 48.65 | 14.0 | 0.5 | 13.0 | 1.0 | 62.3 | 24.5 | 2.00 | 5.04 | 123.6 | 146.4 | 71.02 | 63.0 | 70.07 | 110.33 | 61.3 | 65.0 | 56.7 | 76.2 | 64.2 | 59.6 | 33.4 | 100.0 | 383,915 | 65,237 | 449,152 | 8.9 |
| 2018-03-21 08:17:38 | 25.61 | -9.8 | 6.0 | 15.8 | 2.0 | 47.67 | 13.2 | 5.0 | 9.4 | 3.8 | 63.6 | 24.8 | 2.50 | 4.97 | 123.1 | 146.2 | 74.07 | 58.6 | 73.12 | 108.46 | 62.2 | 61.0 | 59.8 | 65.7 | 65.0 | 56.3 | 33.9 | 100.0 | 383,915 | 65,237 | 449,152 | 8.6 |
| 2018-03-21 08:16:32 | 24.97 | -10.7 | 6.0 | 16.7 | 2.0 | 47.26 | 12.8 | 5.2 | 9.4 | 3.4 | 64.7 | 22.7 | 3.50 | 4.91 | 111.4 | 132.5 | 73.69 | 59.6 | 75.18 | 104.32 | 62.9 | 62.8 | 63.0 | 62.6 | 66.4 | 57.0 | 34.6 | 100.0 | 383,915 | 65,237 | 449,151 | 8.0 |
| 2018-03-21 08:15:32 | 25.12 | -10.5 | 6.1 | 16.6 | 2.0 | 48.25 | 13.7 | 6.2 | 9.4 | 4.3 | 66.0 | 25.0 | 4.10 | 4.82 | 120.6 | 143.8 | 73.79 | 60.1 | 72.37 | 105.10 | 64.6 | 62.5 | 66.9 | 58.6 | 67.4 | 57.9 | 35.4 | 100.0 | 383,914 | 65,237 | 449,151 | 9.3 |
| 2018-03-21 08:14:32 | 24.20 | -11.7 | 6.8 | 18.5 | 2.0 | 48.31 | 13.7 | 5.7 | 10.2 | 3.5 | 67.6 | 24.1 | 4.90 | 4.87 | 117.3 | 139.7 | 72.49 | 65.4 | 73.58 | 99.48 | 67.2 | 66.1 | 70.5 | 60.6 | 36.9 | 100.0 | 383,914 | 65,236 | 449,150 | 9.8 | | |

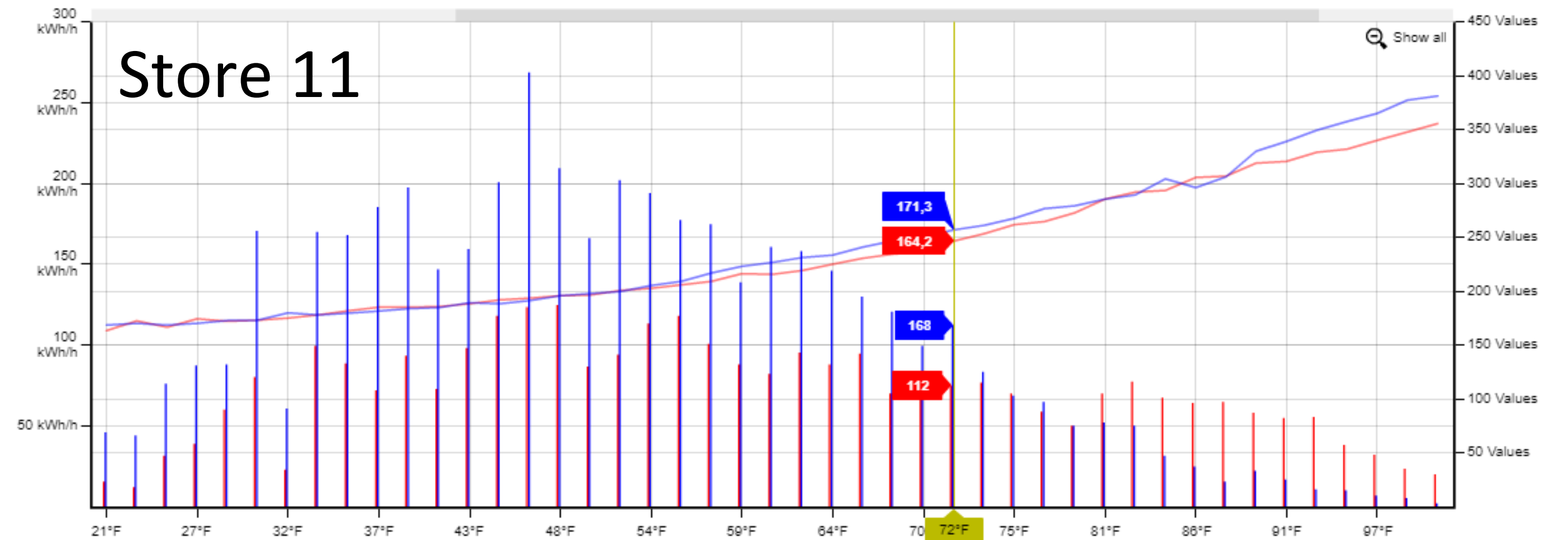
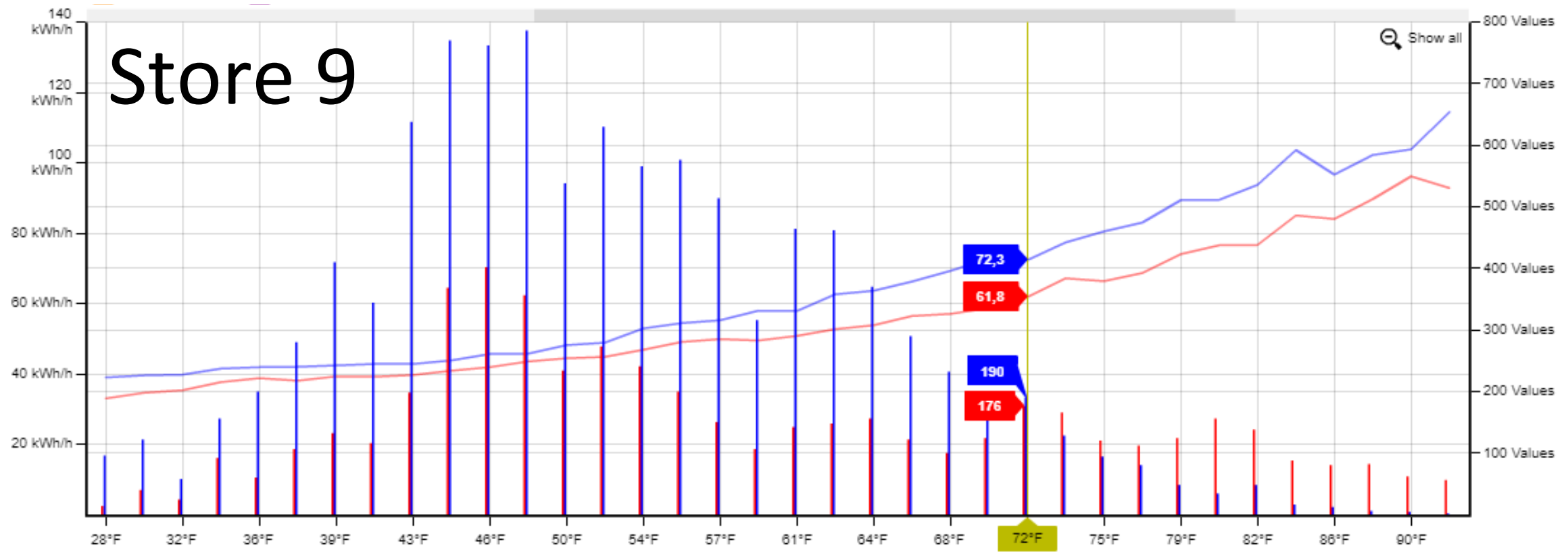
Supermarket performance benchmarking

Energy signatures

Key for benchmarking
of technologies and stores

KWh/h at each outdoor temperature

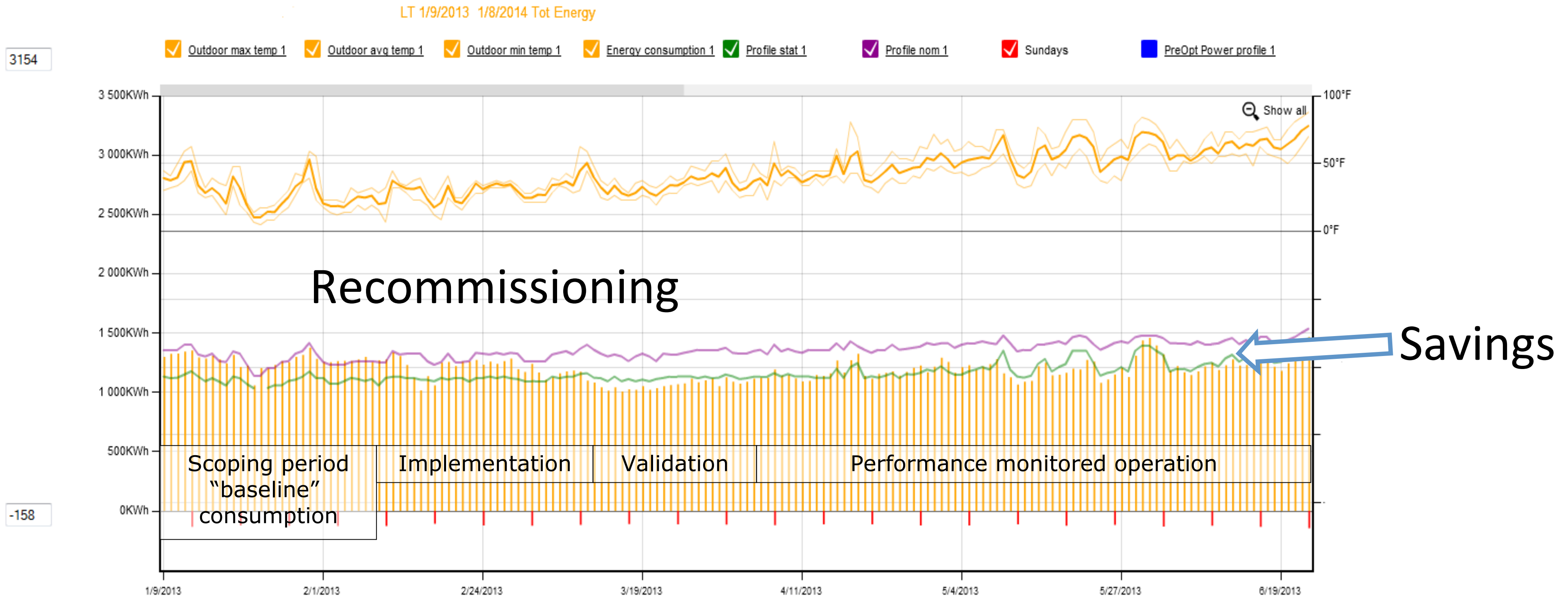
- Result of optimization/measures
- Compare solutions
- Early warning
- Normalization to size, turn-over ++ is required – no size fits all



Supermarket performance benchmarking

Ambient condition impact

Re-Commissioning - result of structured optimisation



Supermarket performance benchmarking

Internationally proven method with 30 years of experience

- Approved for incentives for re-commission and optimization in several regions of USA and Canada
- Proven by leading Universities, Test Institutes, Manufacturers in Europe and US
 - NREL/BPA use ClimaCheck in tests of supermarkets and rooftops
- World leaders use method for measuring and validation:





ATMO
sphere

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Thank you very much!

