Australian perspectives on the "Cold Crunch"

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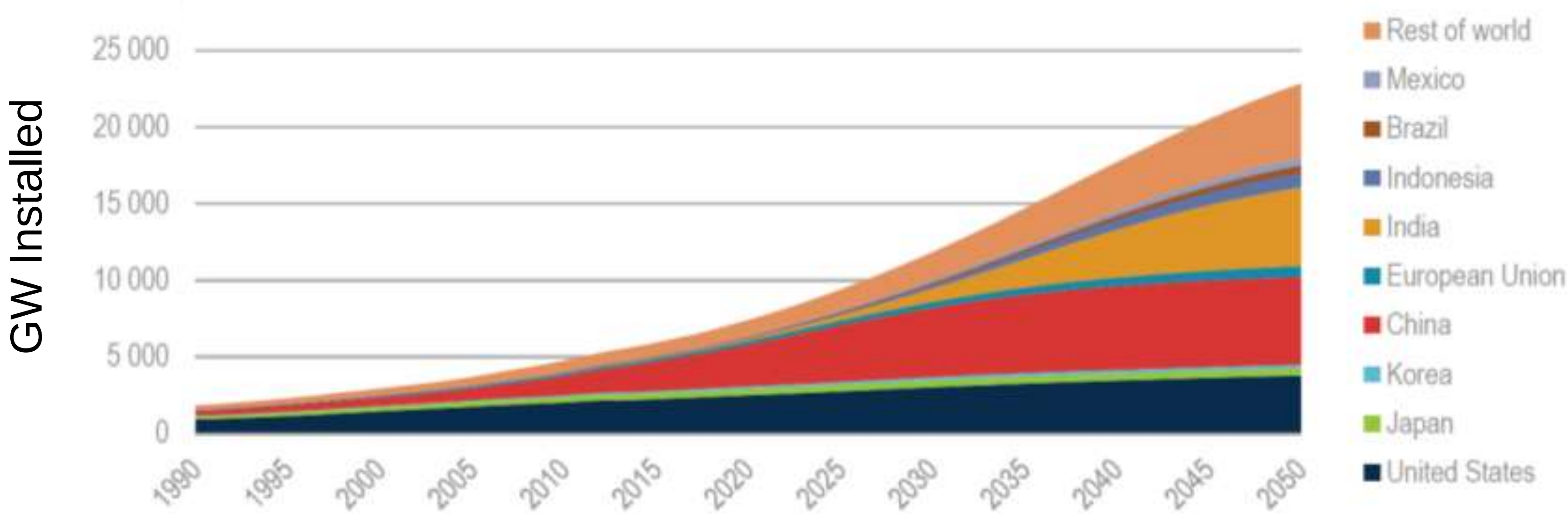
December 2018

Air-conditioning: ‘One of the most critical blind spots in today’s energy debate’

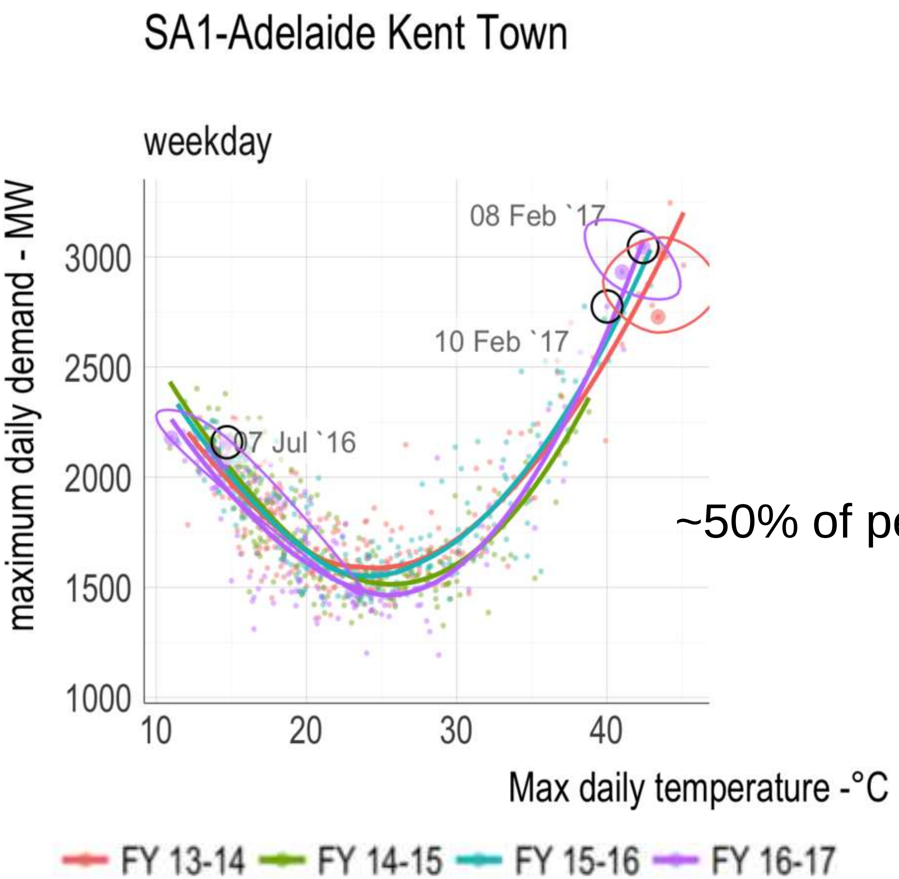
https://www.iea.org/cooling/

Figure 3.2 • Residential AC cooling capacity in the Baseline Scenario by country/region



Consumes ~20% of all electricity produced in Australia

And makes-up an even greater fraction of peak demand



~50% of peak electricity demand

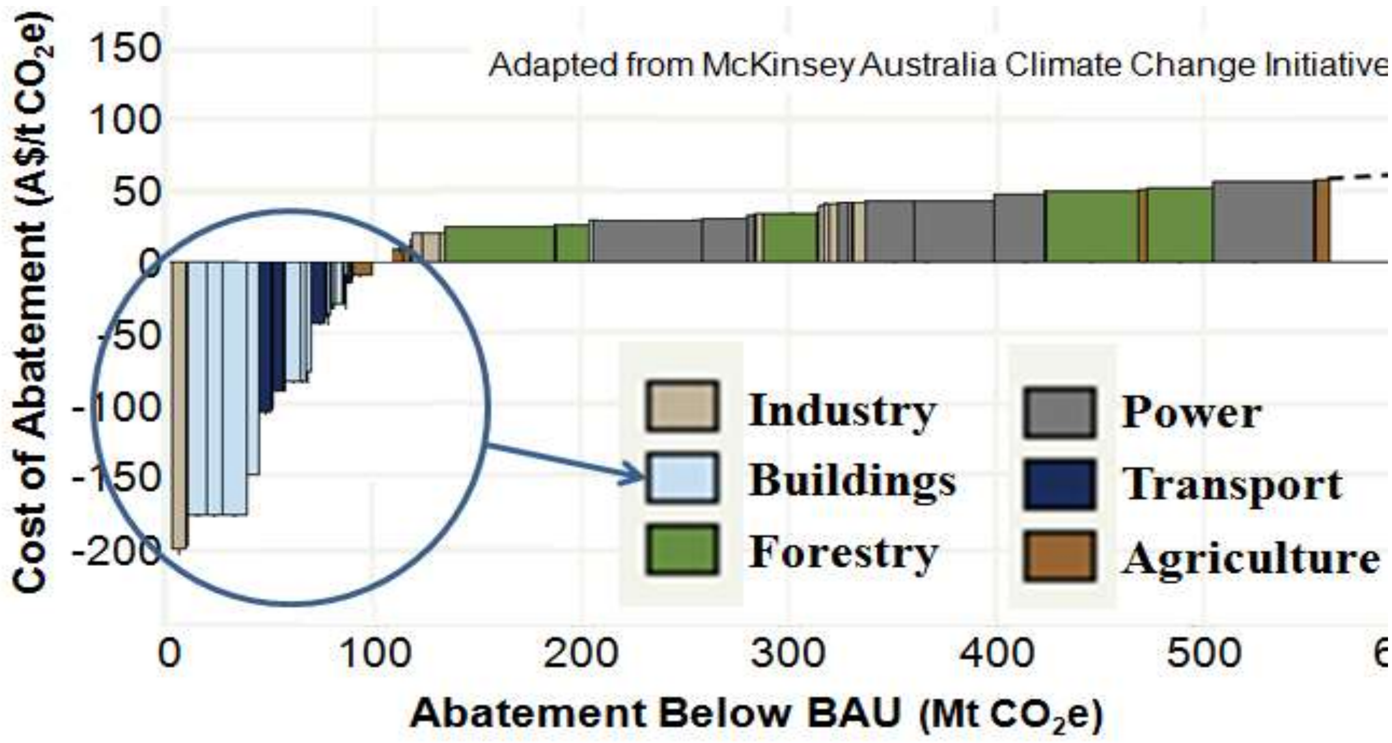
A good (productive) sink for excess PV production?

Figure 4: Impacts of high penetration PV on customer demand profiles

Source: AEMO and Energy Networks Australia 2018, "Open Energy Networks, Consultation Paper".

An enthusiastic Australian property industry

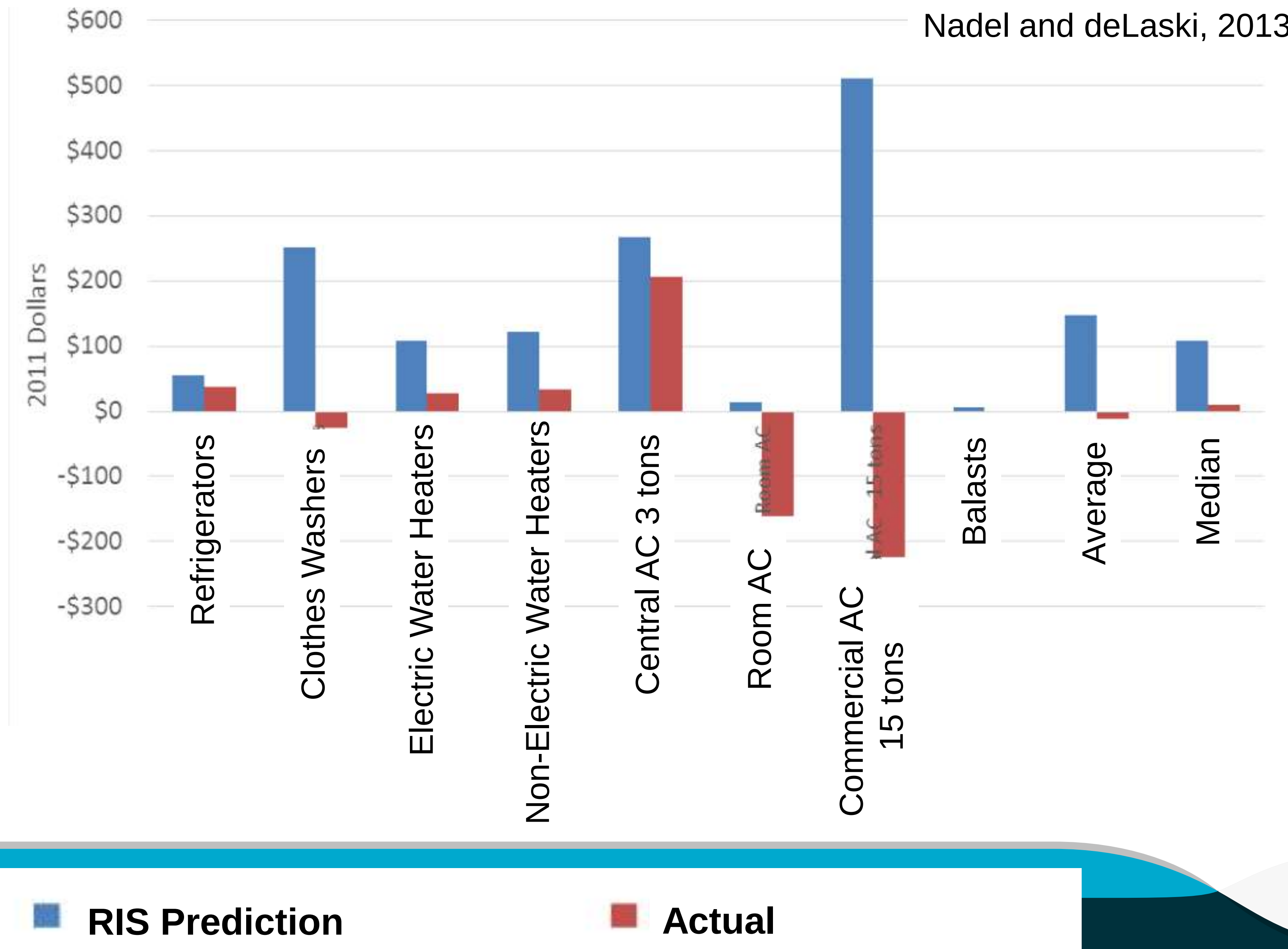
(But it probably isn't thinking of energy economics!)



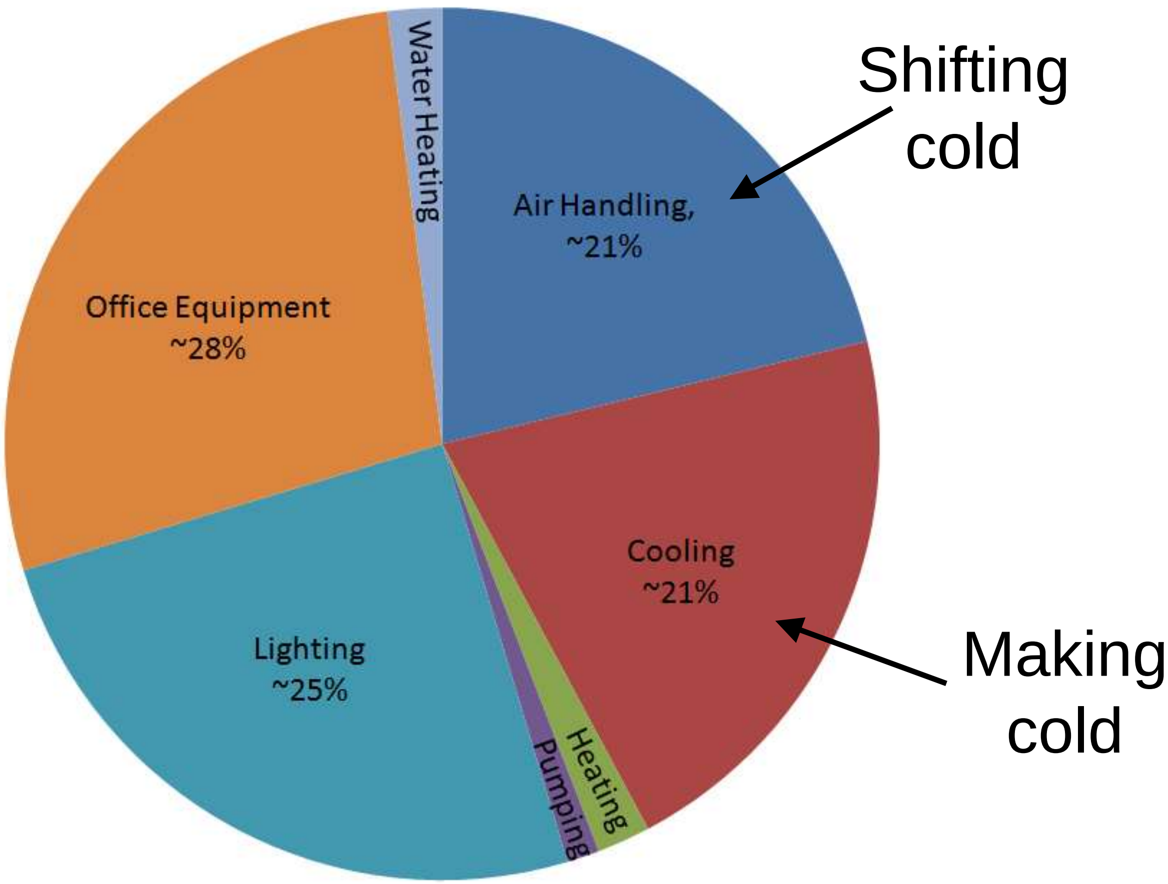
And a disempowered residential sector

Figure 2.3 • SEERs of available residential ACs in selected countries/regions, 2018

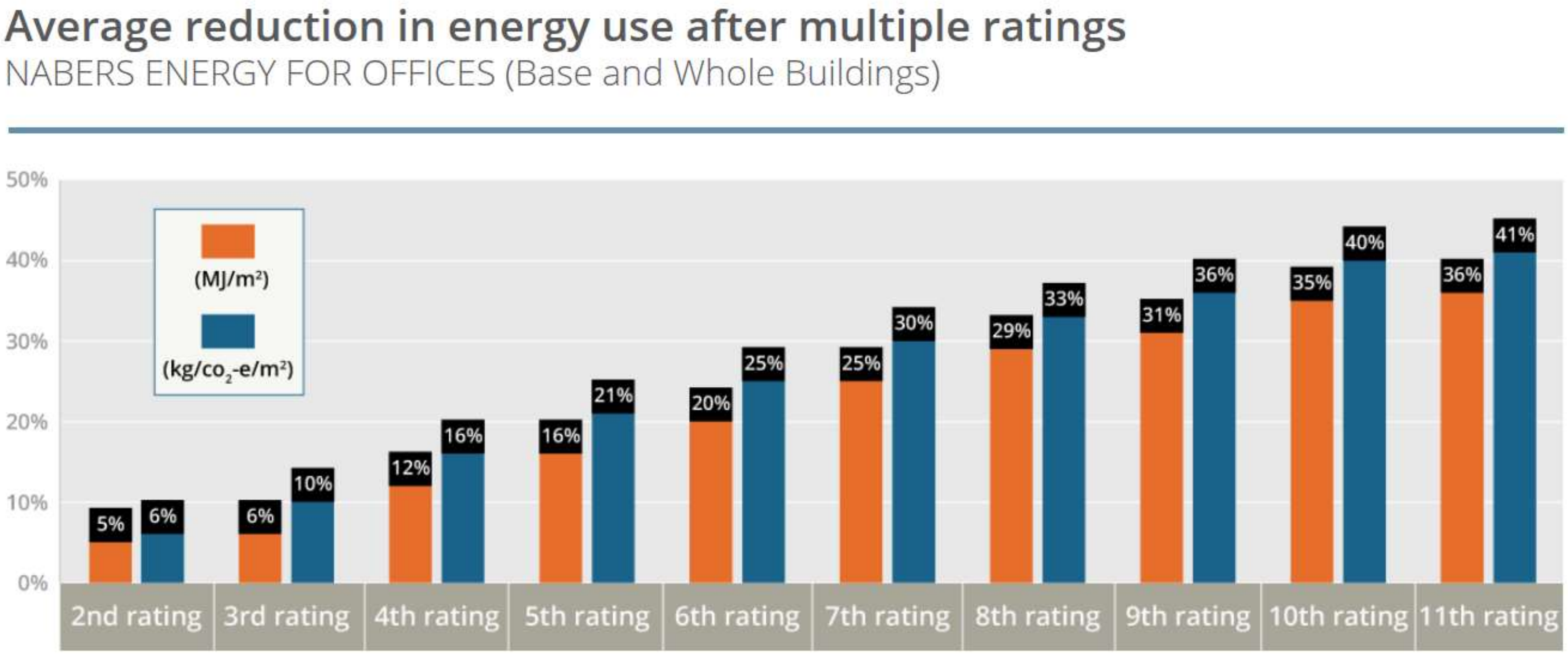
Regulation would seem sensible!



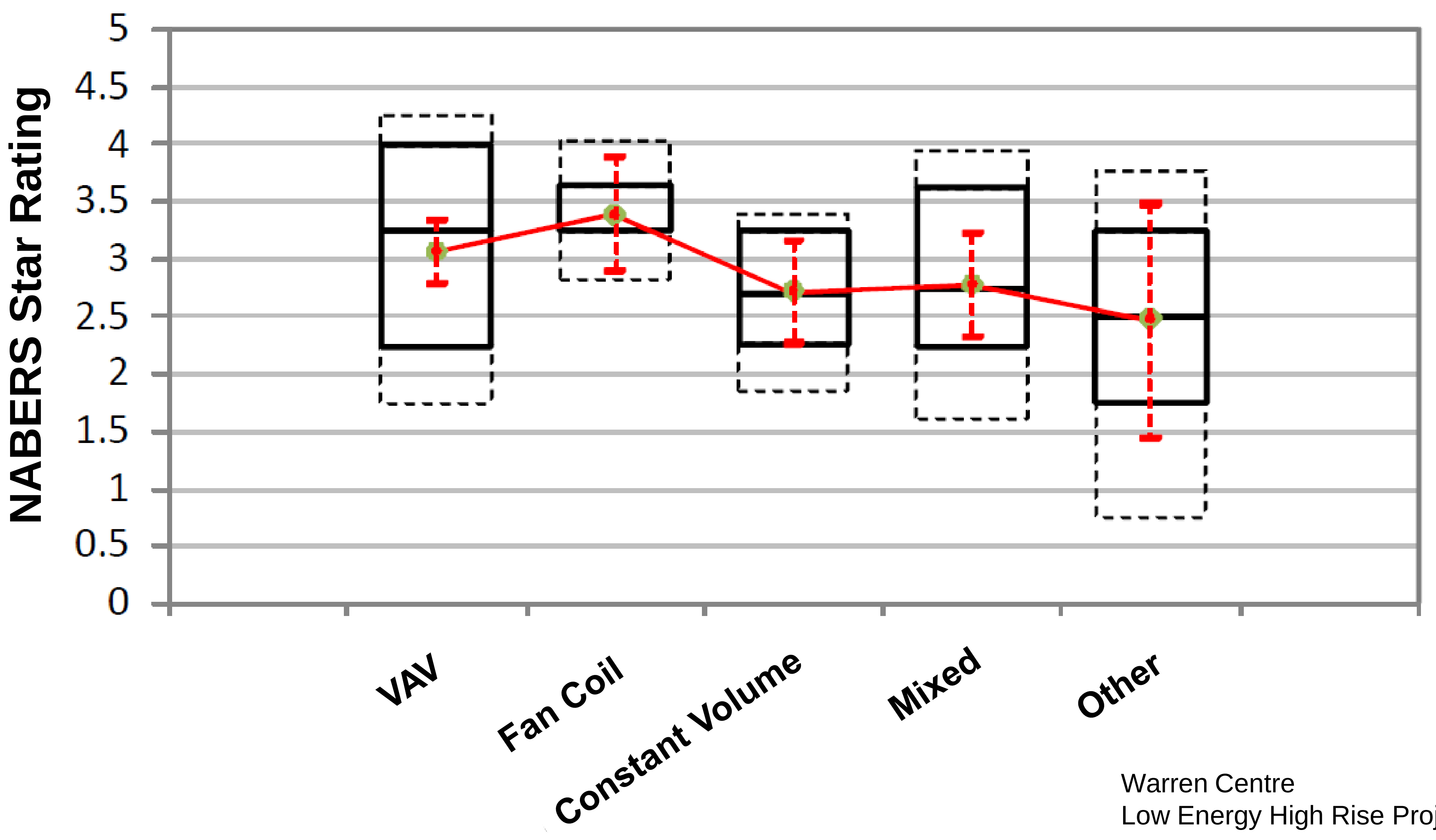
But large buildings require more than just cold production



Smart people can do a lot!



Even when there is no clear technology winner



Warren Centre
Low Energy High Rise Project

Mainstreaming the ‘smarts’ with automated diagnostics

Diagnosis

Stuck cooling coil valve

Supply air temperature should be less than return air temperature

(NIST, 2006)

Symptom

Rule #	Alarm Description	Supply Air Temperature Sensor Error	Return Air Temperature Sensor Error	Mixed Air Temperature Sensor Error	Outdoor Air Temperature Sensor Error	Leaking Cooling Coil Valve	Stuck Cooling Coil Valve	Undersized Cooling Coil	Fouled Cooling Coil	Chilled Water Supply Temperature Too High	Problem with Chilled Water Circulating Pump	Chilled Water not Available to Season	Leaking Heating Coil Valve	Stuck Heating Coil Valve	Undersized Heating Coil	Fouled Heating Coil	Hot Water Supply Temperature Too Low	Problem with Hot Water Circulating Pump	Leaking Mixing Box Damper	Stuck Mixing Box Damper
1	In heating mode, supply air temp should be greater than mixed air temp.	X		X		X	X							X	X	X	X	X		
2	Outdoor air fraction (percentage of outdoor air) is too low or too high.		X	X	X														X	X
3	Heating coil valve command is fully open and supply air temp error exists.	X				X	X							X	X	X	X	X		
4	Heating coil valve command is fully open. If heating load increases, supply air temp will drift from setpoint.	X				X	X							X	X	X	X	X		
5	Outdoor air temp is too warm for cooling with outdoor air.	X			X															
6	Supply air temp should be less than return air temp.	X	X										X	X						
7	Supply and mixed air temp should be nearly the same.	X		X		X	X						X	X						
8	Outdoor air temperature is too cool for mechanical cooling with 100% outdoor air.	X			X								X	X					X	X
9	Outdoor air enthalpy is too great for mechanical cooling with 100% outdoor air.																			
10	Outdoor and mixed air temp should be nearly the same.			X	X														X	X
11	Supply air temp should be less than mixed air temp.	X		X			X	X	X	X	X	X	X	X						
12	Supply air temp should be less than return air temp.	X	X				X	X	X	X	X	X	X	X						
13	Cooling coil valve command is fully open and supply air temp error exists.	X					X	X	X	X	X	X	X	X						
14	Cooling coil valve command is fully open. If cooling load increases, supply air temp will drift from setpoint.	X					X	X	X	X	X	X	X	X						
15	Outdoor air enthalpy is too low for mechanical cooling with minimum outdoor air.																			
16	Supply air temp should be less than mixed air temp.	X		X			X	X	X	X	X	X	X	X						
17	Supply air temp should be less than return air temp.	X	X				X	X	X	X	X	X	X	X						
18	Outdoor air fraction (percentage of outdoor air) is too low or too high.		X	X	X														X	X
19	Cooling coil valve command is fully open and supply air temp error exists.	X					X	X	X	X	X	X	X	X						
20	Cooling coil valve command is fully open. If cooling load increases, supply air temp will drift from setpoint.	X					X	X	X	X	X	X	X	X						
21	Heating coil valve, cooling coil valve, and mixing box dampers are all modulating simultaneously.																			
22	Heating coil valve and cooling coil valve are both modulating simultaneously.																			
23	Heating coil valve and mixing box dampers are both modulating simultaneously.																			
24	Cooling coil valve and mixing box dampers are both modulating simultaneously.																			
25	Persistent supply air temp error exists.																			

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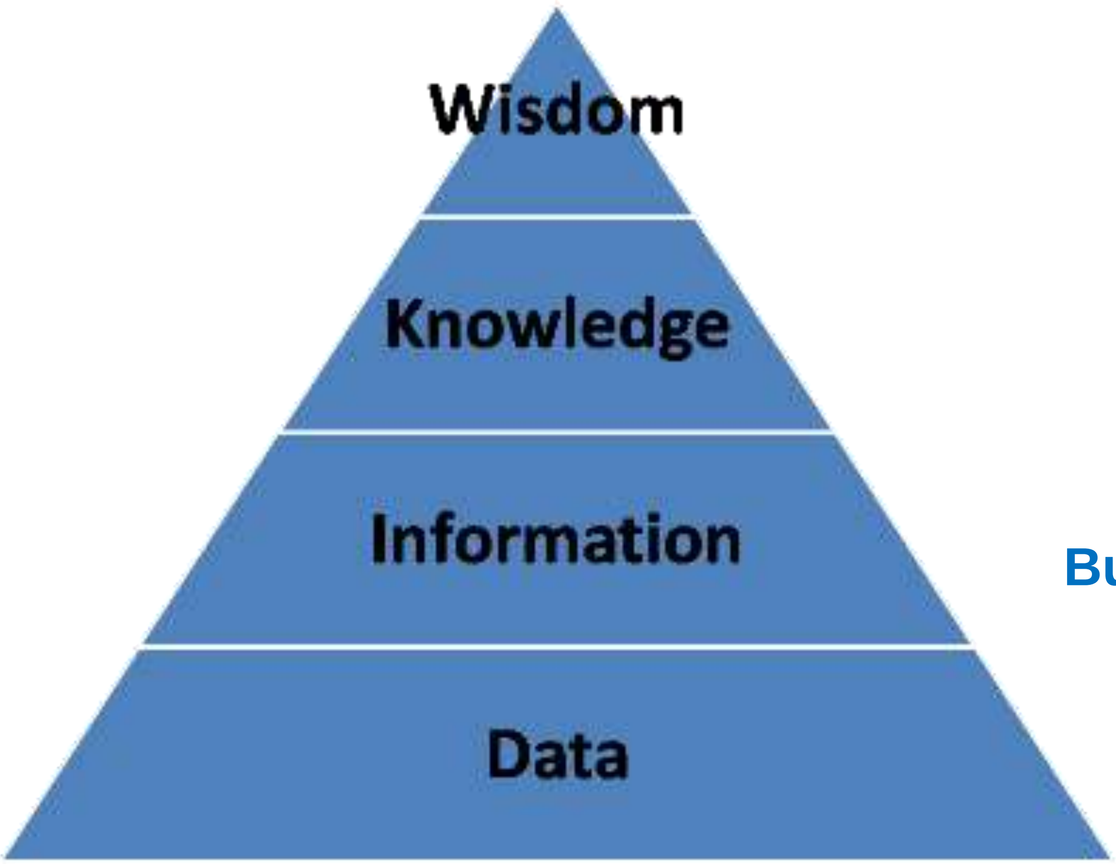
“You cant manage what you don’t measure”



Empowered Human
Digital Platforms

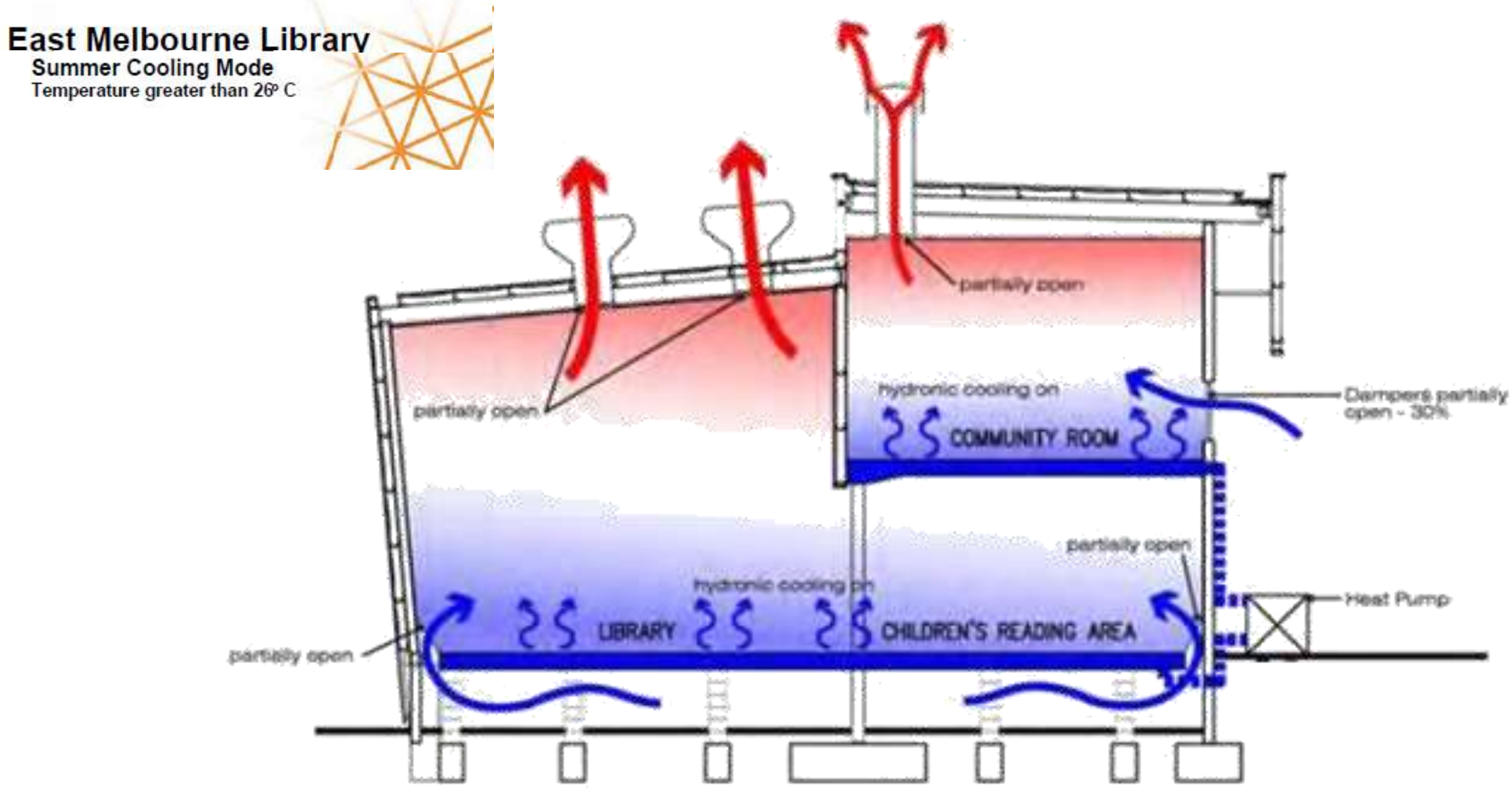
Artificial Intelligence
Mathematical Modelling

Cloud Computing
Building Automation Systems

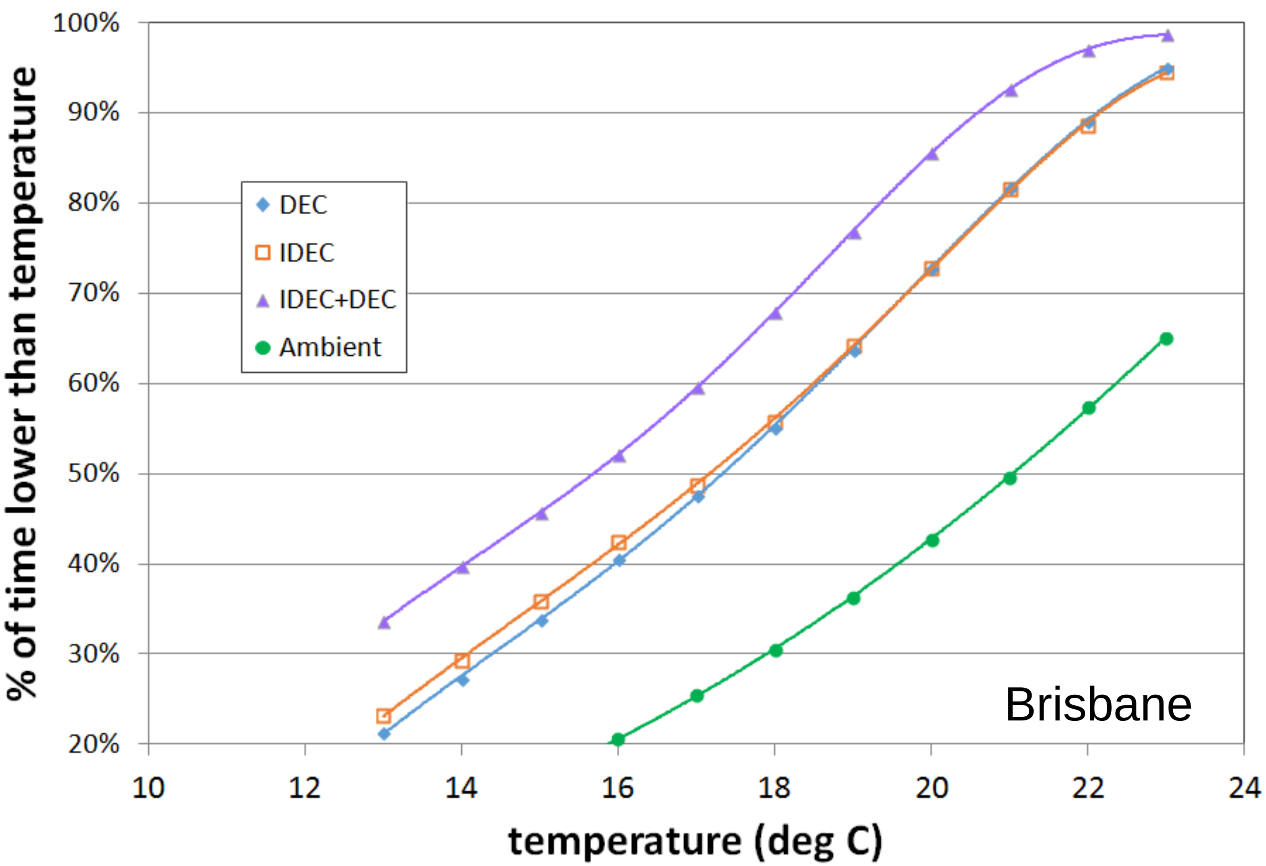
IoT Sensors
Occupant Mobile Devices

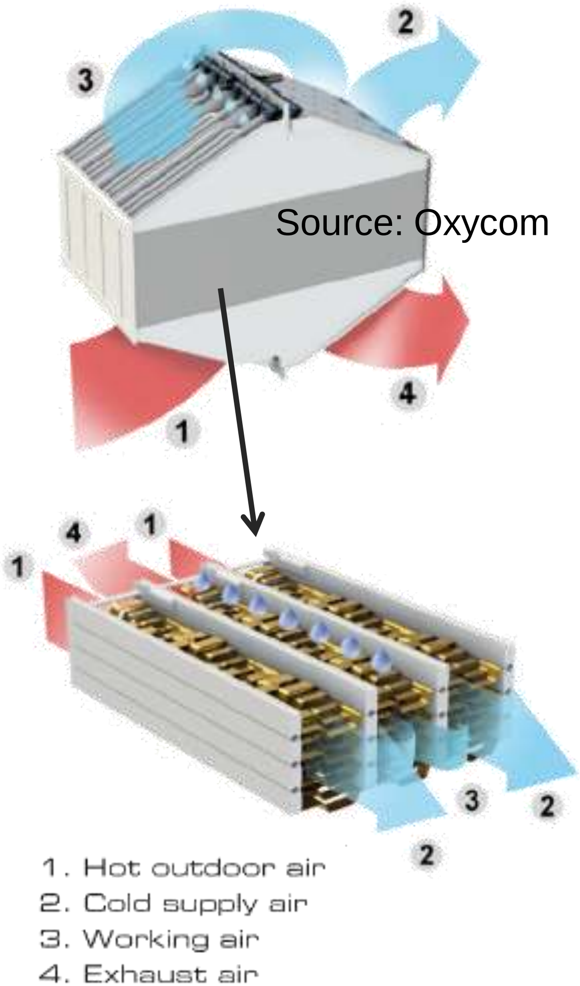
HVAC-as-a-Service

Going beyond incremental improvements with Integrated Design

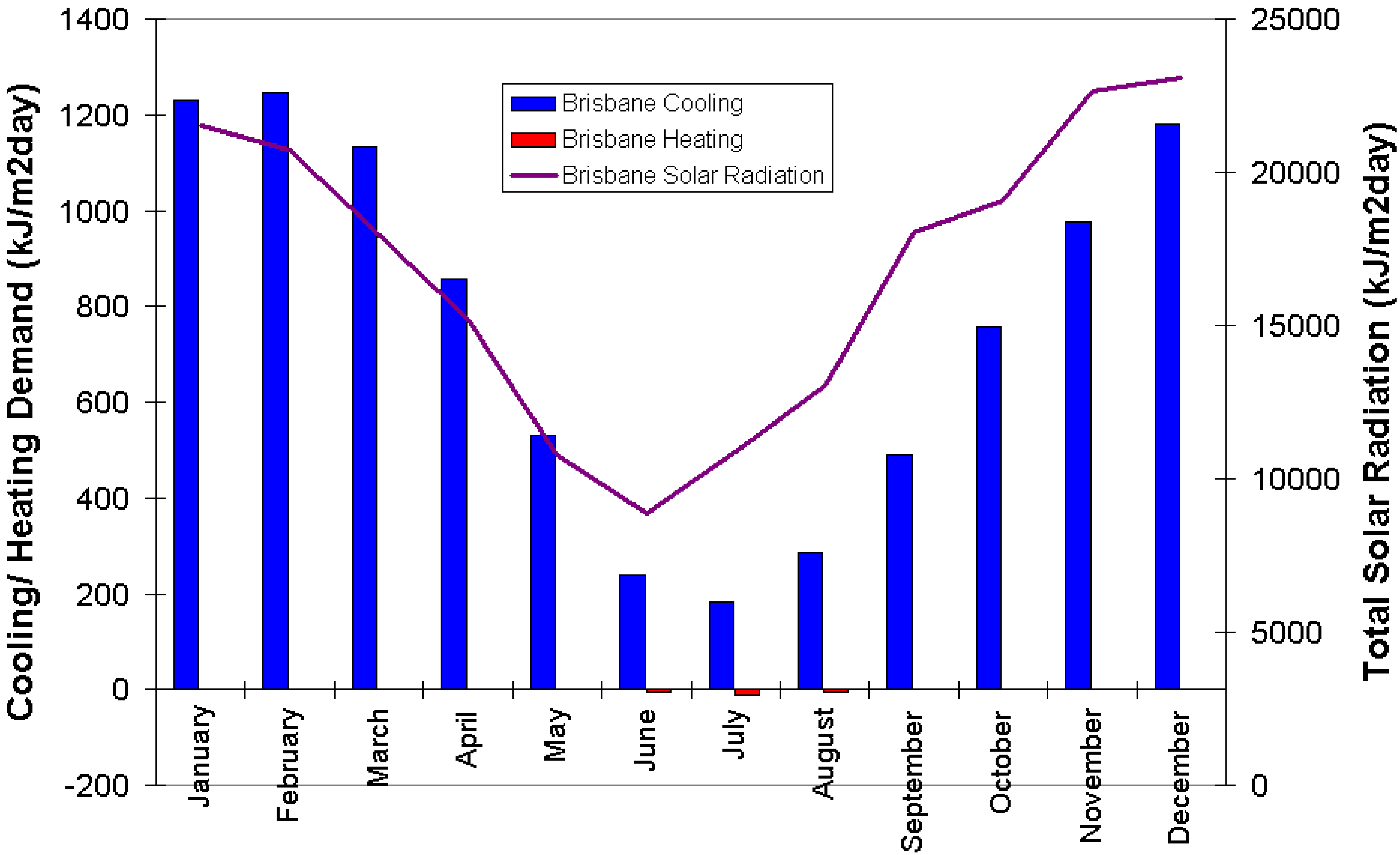


"Free" cooling is available most of the year

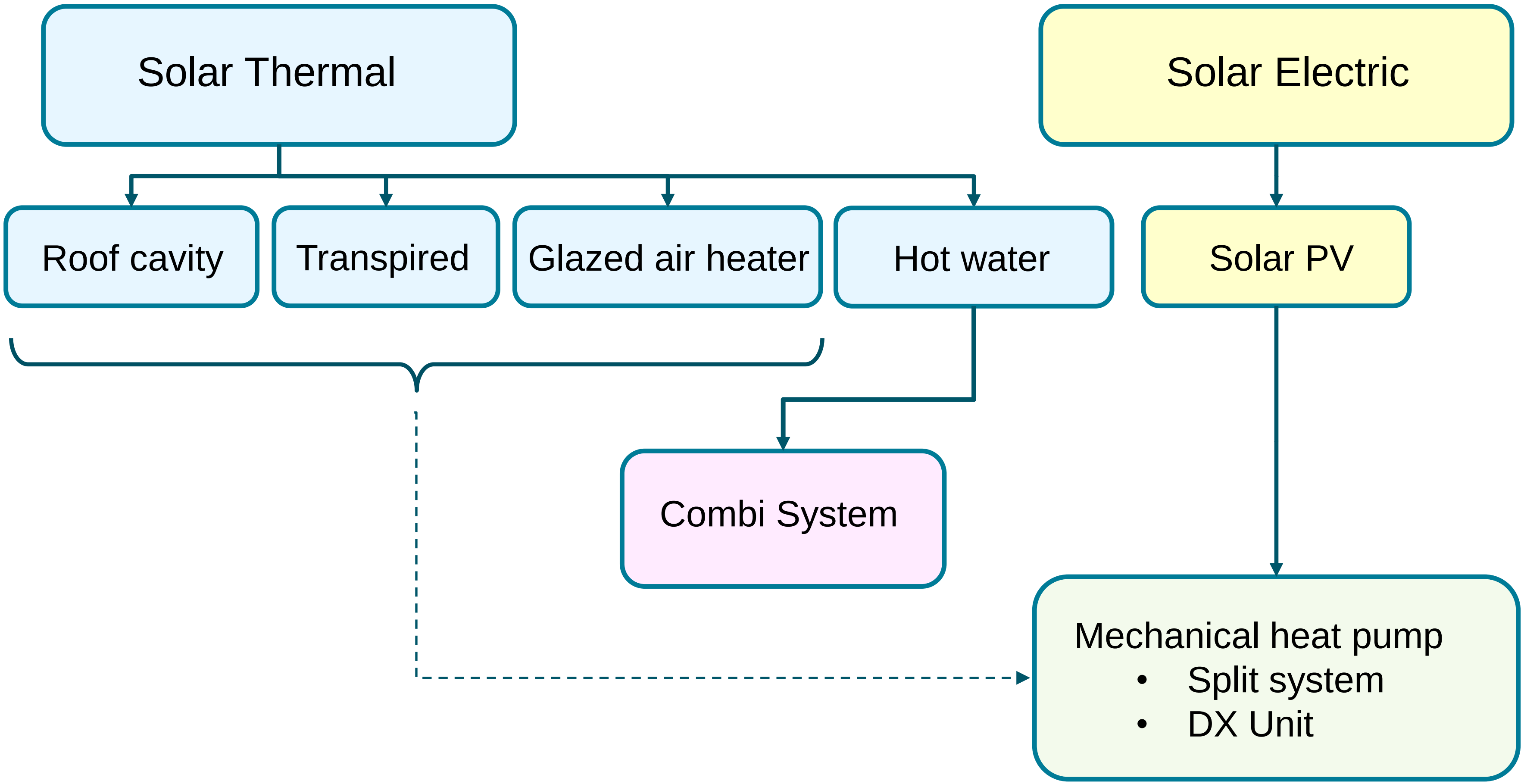




What about solar heating and cooling?



Routes to delivering solar space heating



Combi-systems beget solar cooling systems?

- Increased market share of solar combi-systems: Solar thermal system for hot water and support of the heating system
- Collector area typically ~10 – 15 m^2
- 800 - 1200 Litre buffer storage volume
- Solar fraction for total heat demand
  - 20 – 35 % in central Europe
  - 30-60 % in southern Europe
- Market share ~ 40 % of newly installed systems in Germany (collector area)

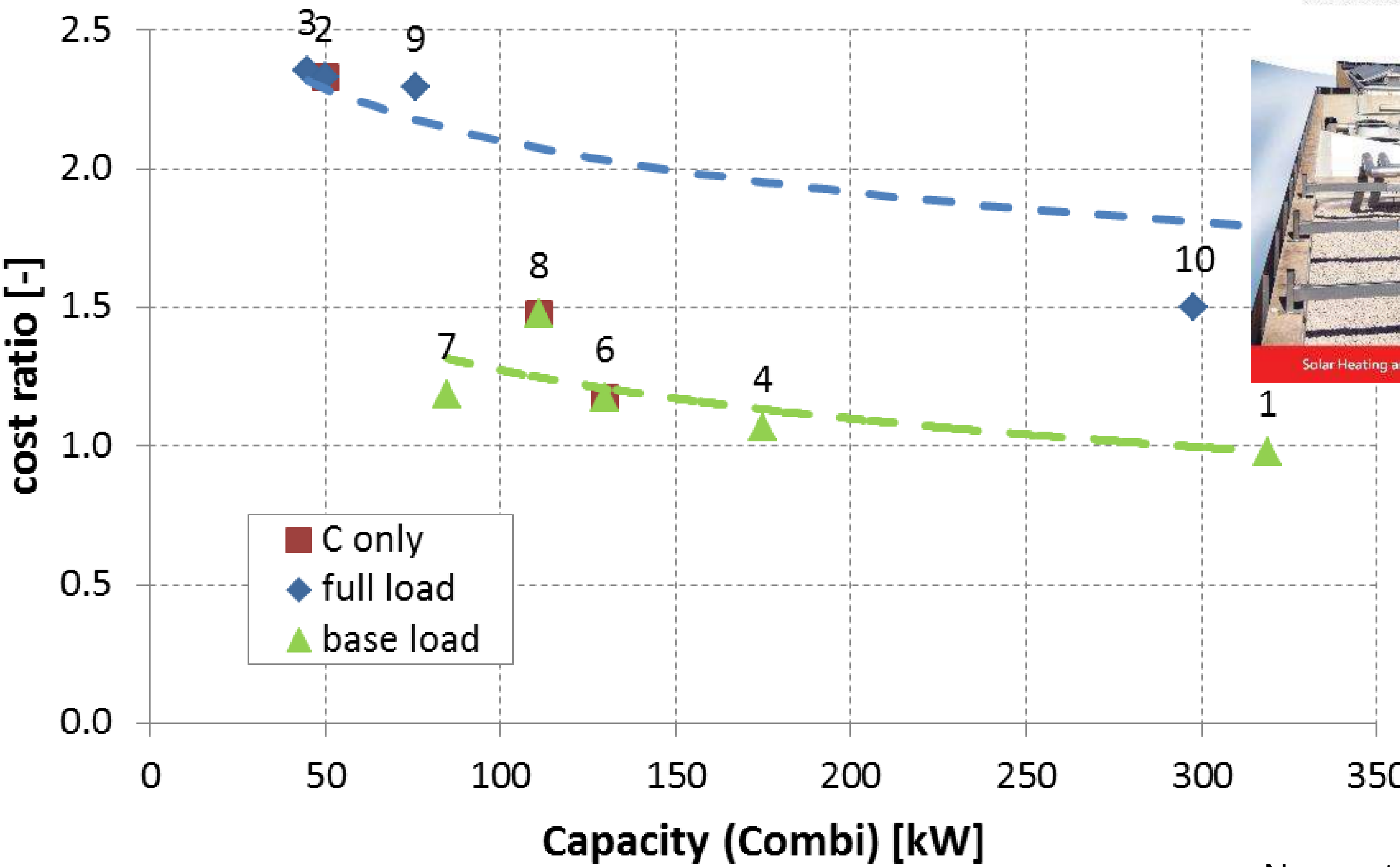
Fraunhofer Institut Solare Energiesysteme

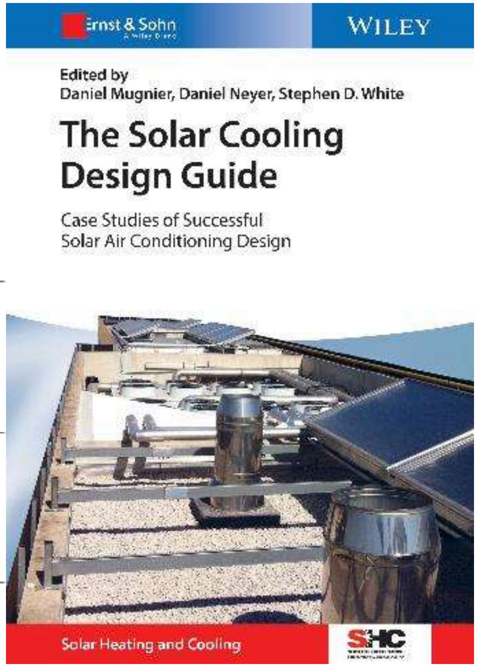
SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 38 Solar Air-Conditioning and Refrigeration

CSIRO

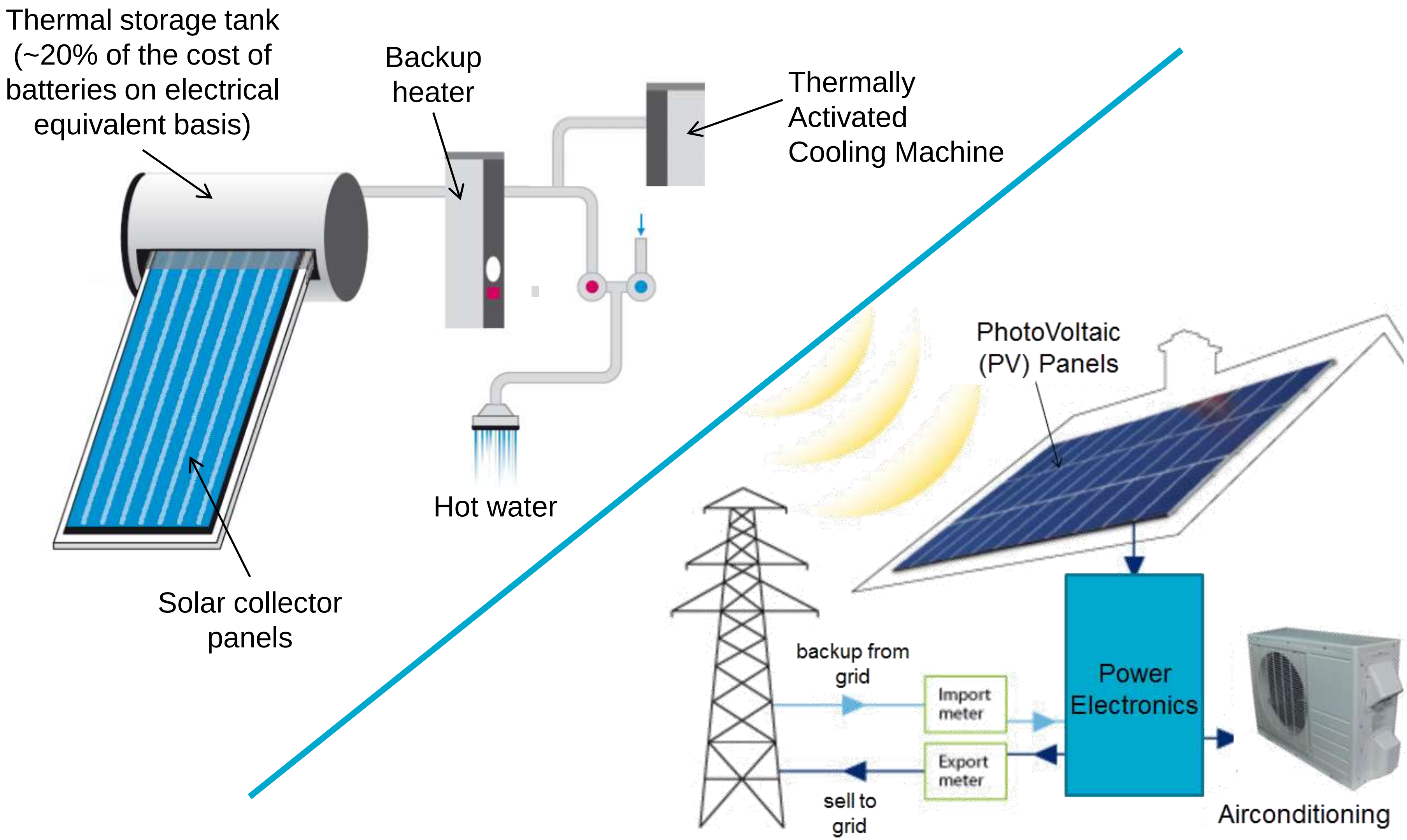
Economics





Neyer et al, 2015

Solar PV or solar thermal



Separate PV and AC (grid acting as buffer) vs Connected PV and AC (off-grid/ self consumption)?

Is this "Solar Airconditioning" **or** "Solar AND Airconditioning" ?

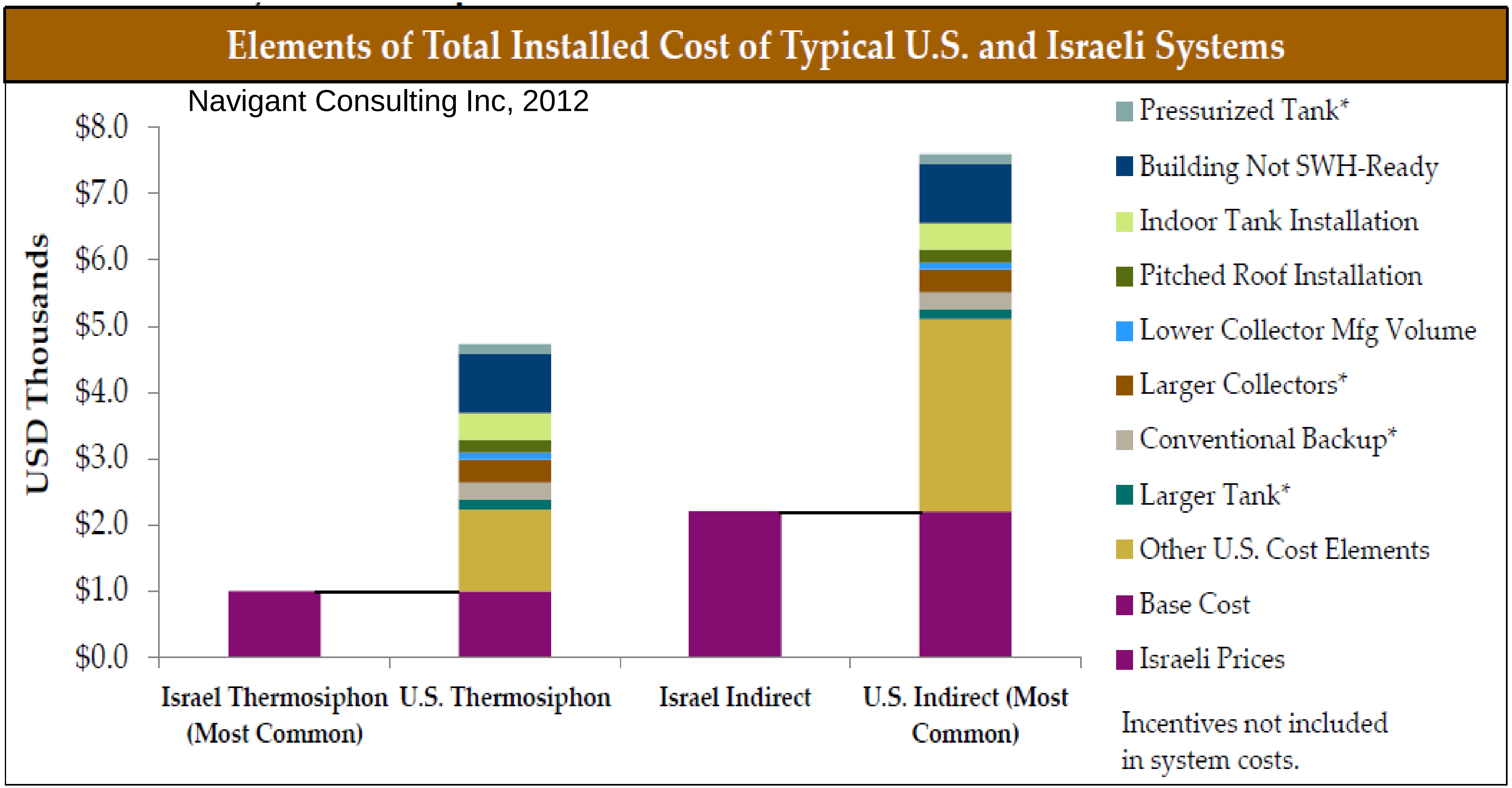
Potential benefits (beyond simple energy savings)

	Electricity system benefit	Consumer benefit	Disadvantages

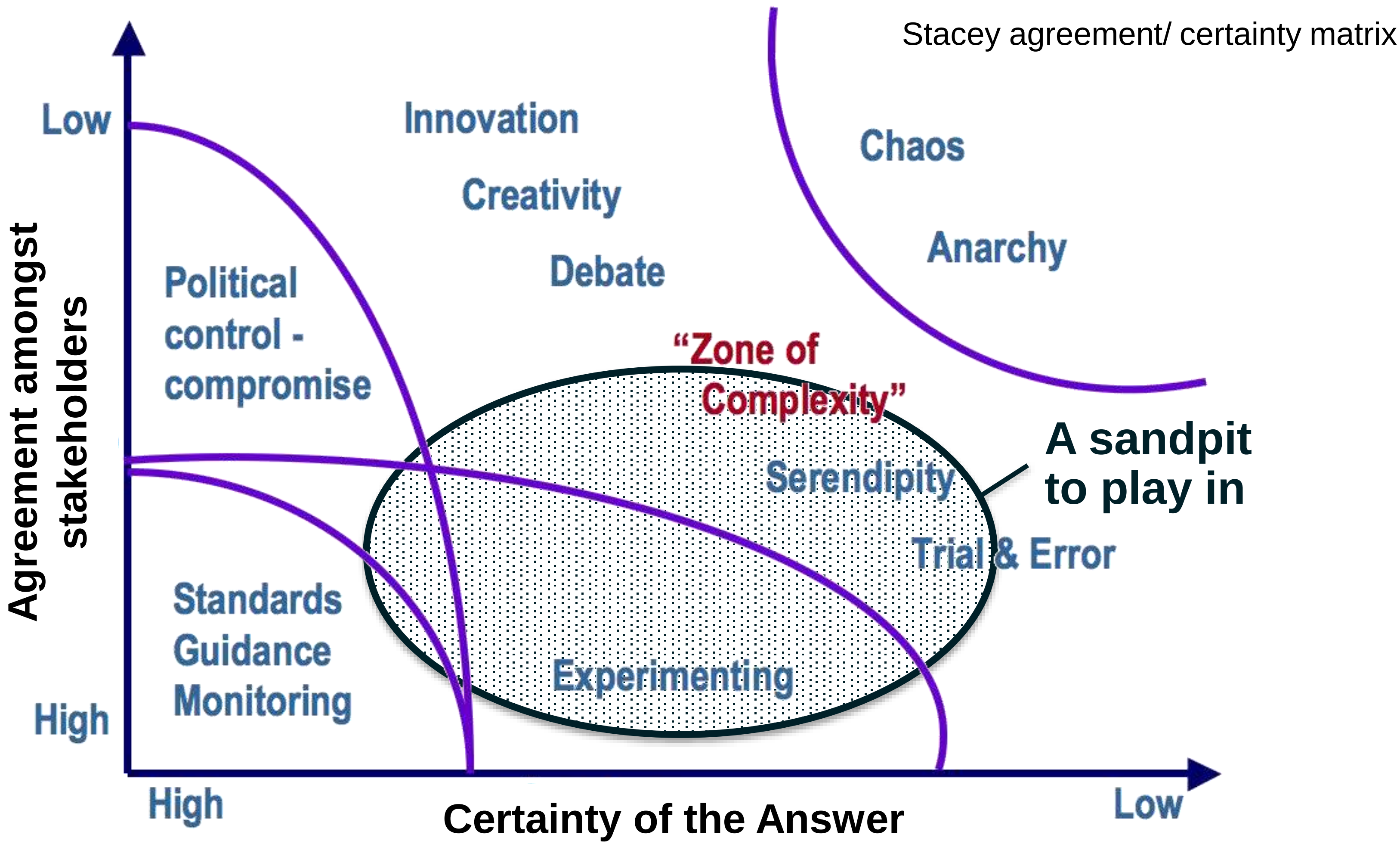
Autonomous
100% off grid solar PV/AC
	• Reduced peak demand
	• No reverse power flow
	  • Safety
	  • Voltage
	• Slow ramp rates
		Residential:
		• leave it permanently on = guilt free luxury
		Commercial
		• Solar cooling efficiency increase at part load
		I don't need to inform my electricity utility
			• Wasted electricity if airconditioning is not required
			• Needs batteries to manage fluctuations

100% self consumption of Solar + grid backup	• Reduced peak demand • No reverse power flow	I don't need to inform my electricity utility	Wasted electricity if airconditioning is not required
Solar PV self consumption with **grid export**/import	Reduced peak demand	Get full value for electricity	Lack of advantages

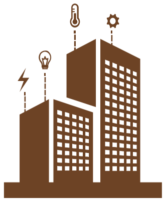
But making an industry BAU leap is tricky
(solar hot water example)



Supporting a transition



The Affordable Heating and Cooling Innovation Hub (*i*-Hub)



Buildings to Grid Data Clearing House

Data, Software and Automation Companies

THE INNOVATION HUB

iHUB

FOR AFFORDABLE HEATING AND COOLING

Living laboratory accelerators

Green proving grounds

Product Manufacturers and Suppliers

>100MW of flexible load identified and proven

Integrated Design Studios

Design Consultants

Summary

- Australia is making good (but incremental) progress toward low energy HVAC, despite a lack of regulatory ambition
- 'Smart' automation and diagnostic technology can provide **Demand Response** and address skills deficits
  - Expect significant digital innovation.
- Deep energy savings will require more innovative design solutions.
  - Integrated design is a key enabler, and a willingness to 'experiment' with new designs
- Solar airconditioning has electricity system benefits over solar *and* airconditioning
- A proposed Australian Mission Innovation 'Affordable Heating and Cooling Innovation Hub' (***i***-Hub) aims to provide the necessary sandpit for accelerating industry transition

Thank you

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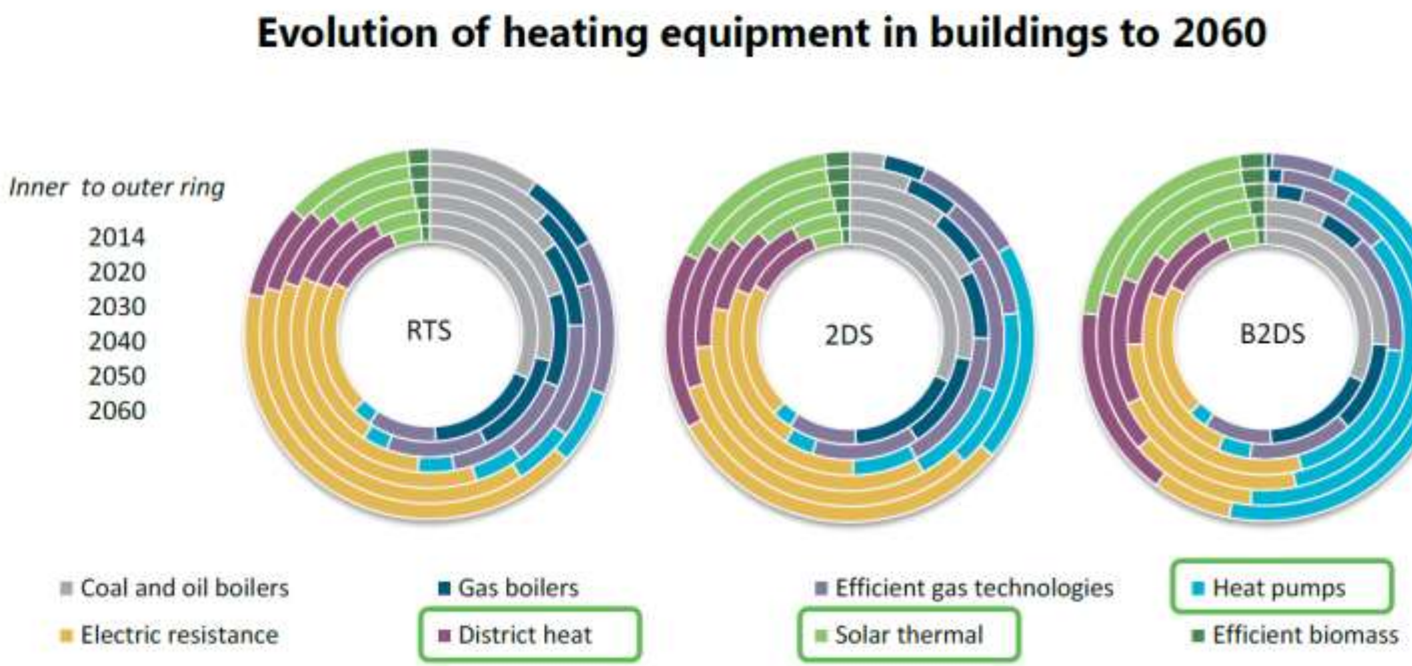
An IEA view of the future….

Heating equipment



Heat pumps, solar thermal and district heat is key to B2DS

Source: IEA Energy Technology Perspectives 2017