Meeting the demands of network peak demand: Implementing a model of a complex socio-technical system using MS Excel

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Project: *Electricity Demand Side Management: Models, Optimisation and Customer Engagement*

ARC Linkage Projects scheme

Peak demand

What is it?

- Between 4pm and 8pm, we all tend to do exactly the same thing.
  - We make dinner,
  - turn on the air-conditioner and
  - the TV,
  - do our washing and
  - put on the dishwasher …

Network peak demand

- Occurs only a few times a year
- Will continue to increase
  - Population increases
  - More high energy use appliances.
    - » air conditioning
    - » swimming pool pumps
    - » dishwashers

What impact?

Without intervention

- Expenditure of **$15 billion**
  - Generation
  - Transmission
  - Distribution

(Ergon, 2009)

Asset base value per customer has **doubled** over the 10 years from 2001 to 2011.

Energy is a complex system

- *For every complex problem, there is a solution that is simple, neat, and wrong.*
- H.L. Mencken

- Drivers of energy use
- Complexity of the interactions
  - consumers and energy technologies.

What can be done?

Cost-effective reduction for residential electricity?

Managing this growth in peak demand by

- shifting or reducing demand

Using approaches which combine

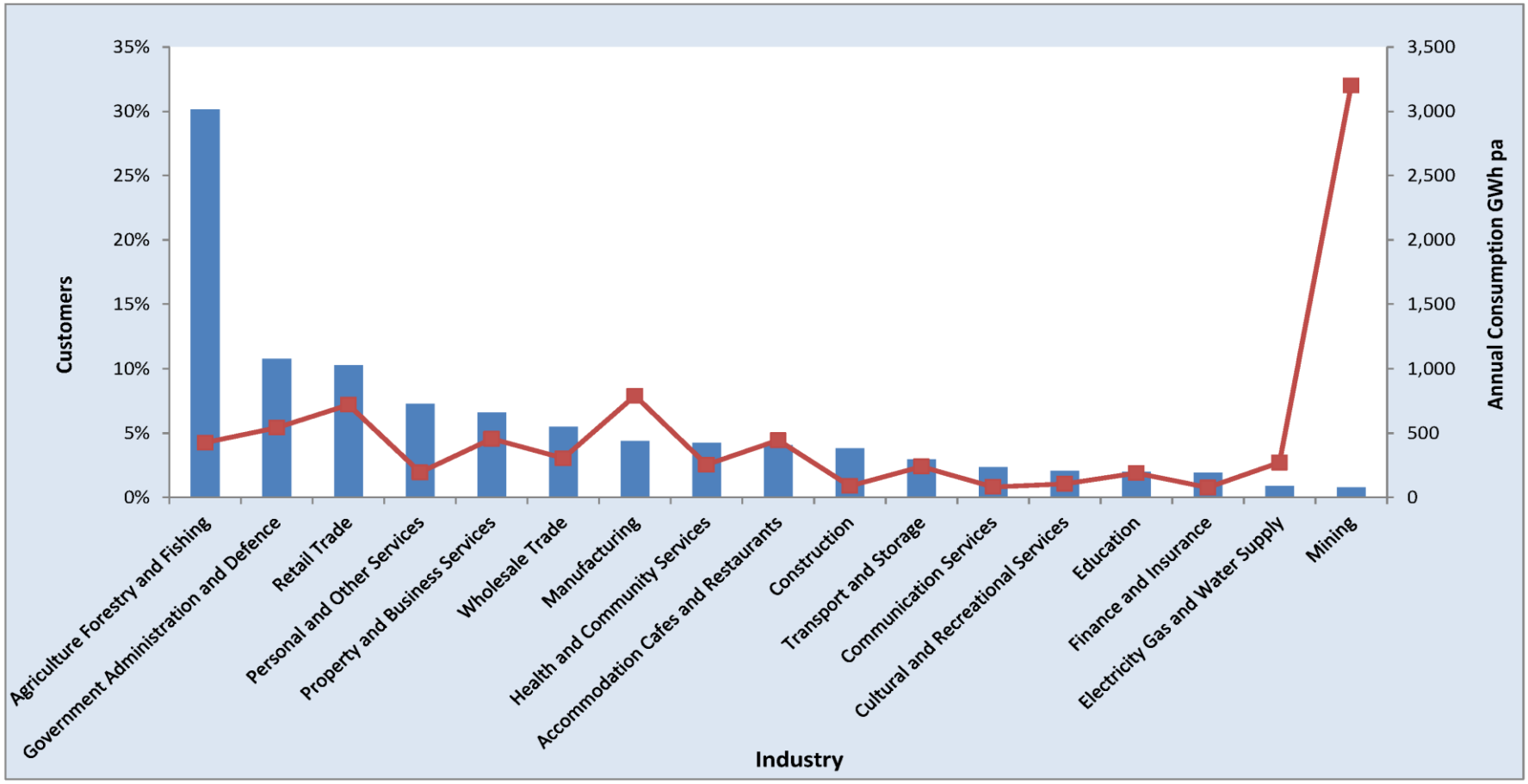
- technical solutions
- behavioural solutions

$$I = tpn$$

I	Impact
t	technical impact
p	probability of change
n	number of people who may change

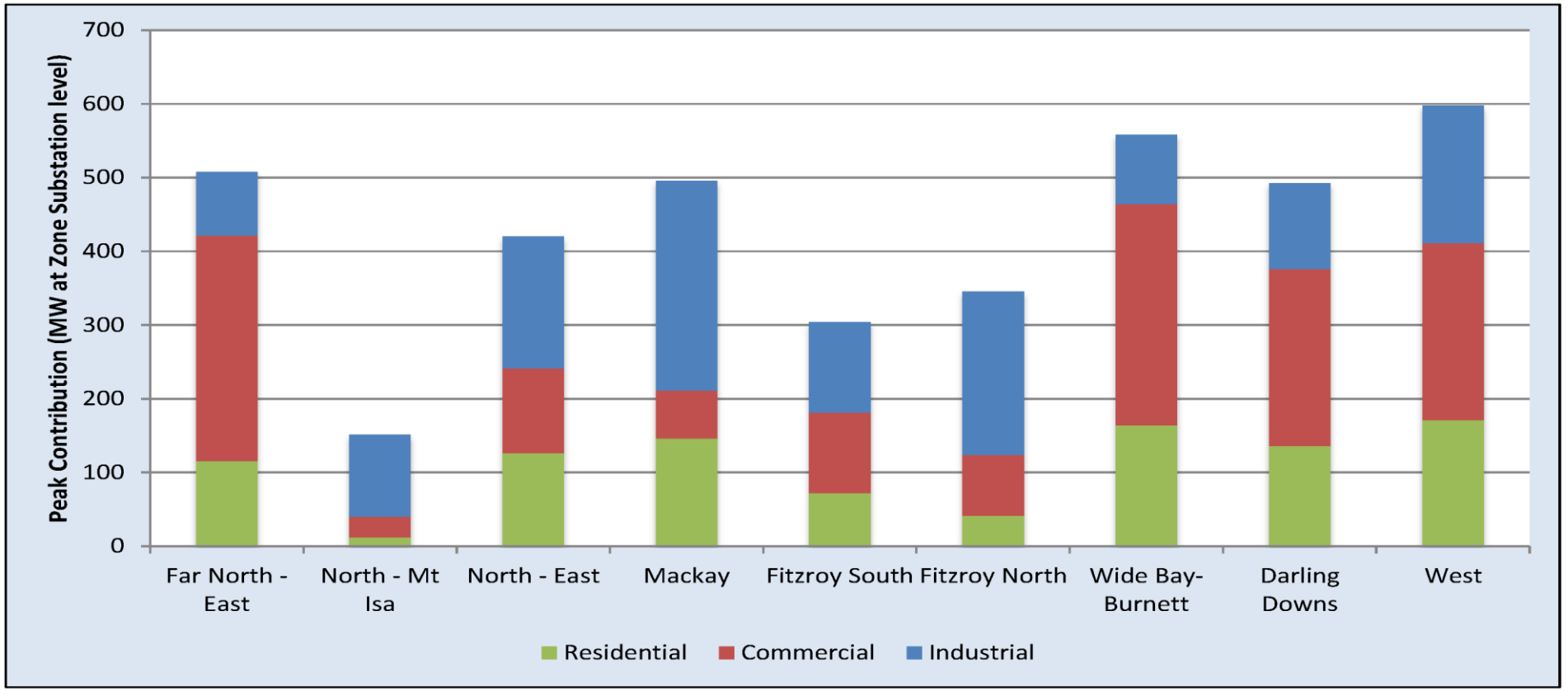
Objectives of the Bayesian Network model

- Create a ‘conceptual map’
  - social and
  - technical drivers
- Bring together disparate knowledge
- Quantify the ‘map’
- Identify key drivers and impacts



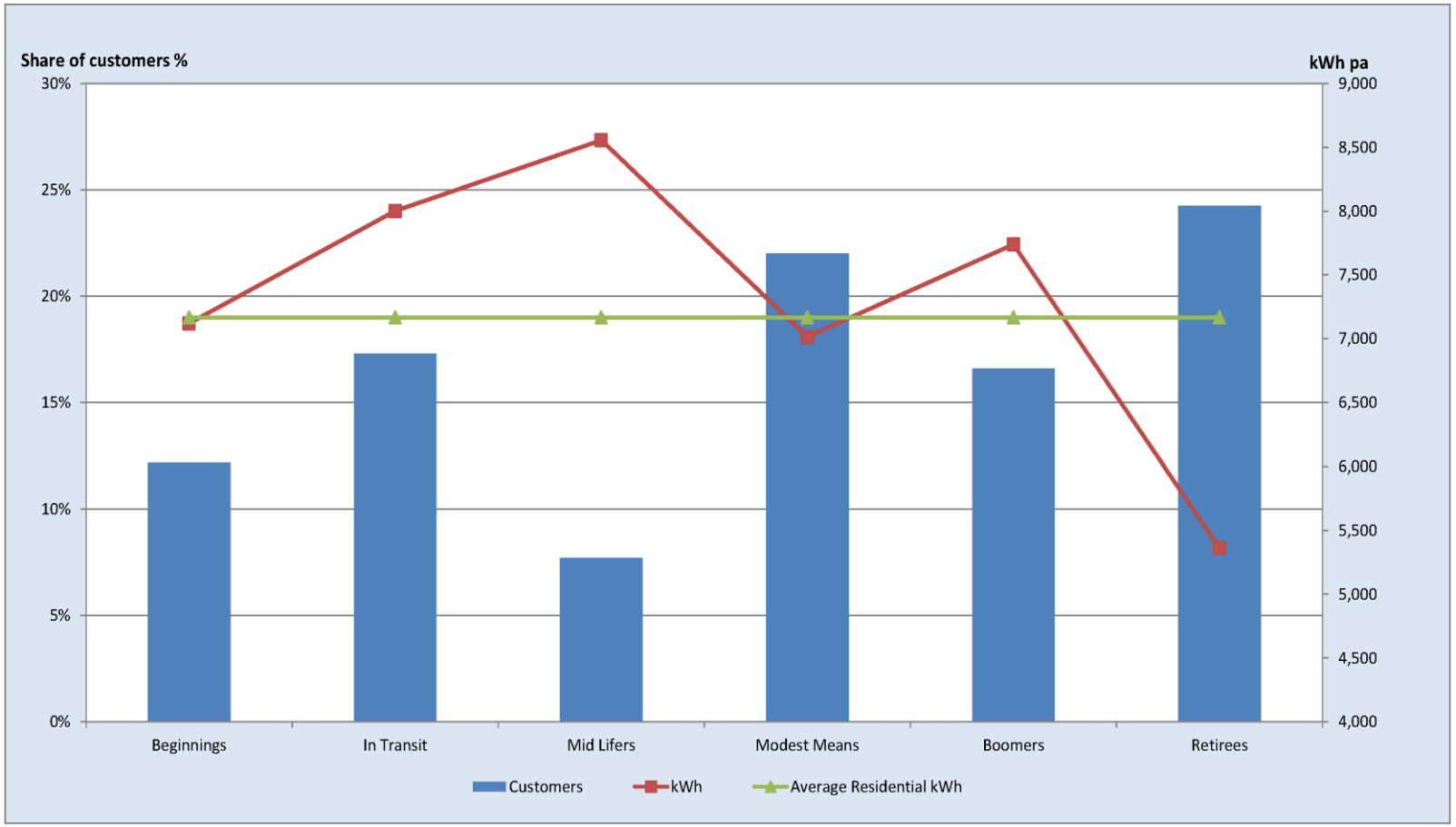
Commercial and Industrial consumption by segments 2011/12 (Ergon Energy)

Different locations peak consumption customer segment proportions



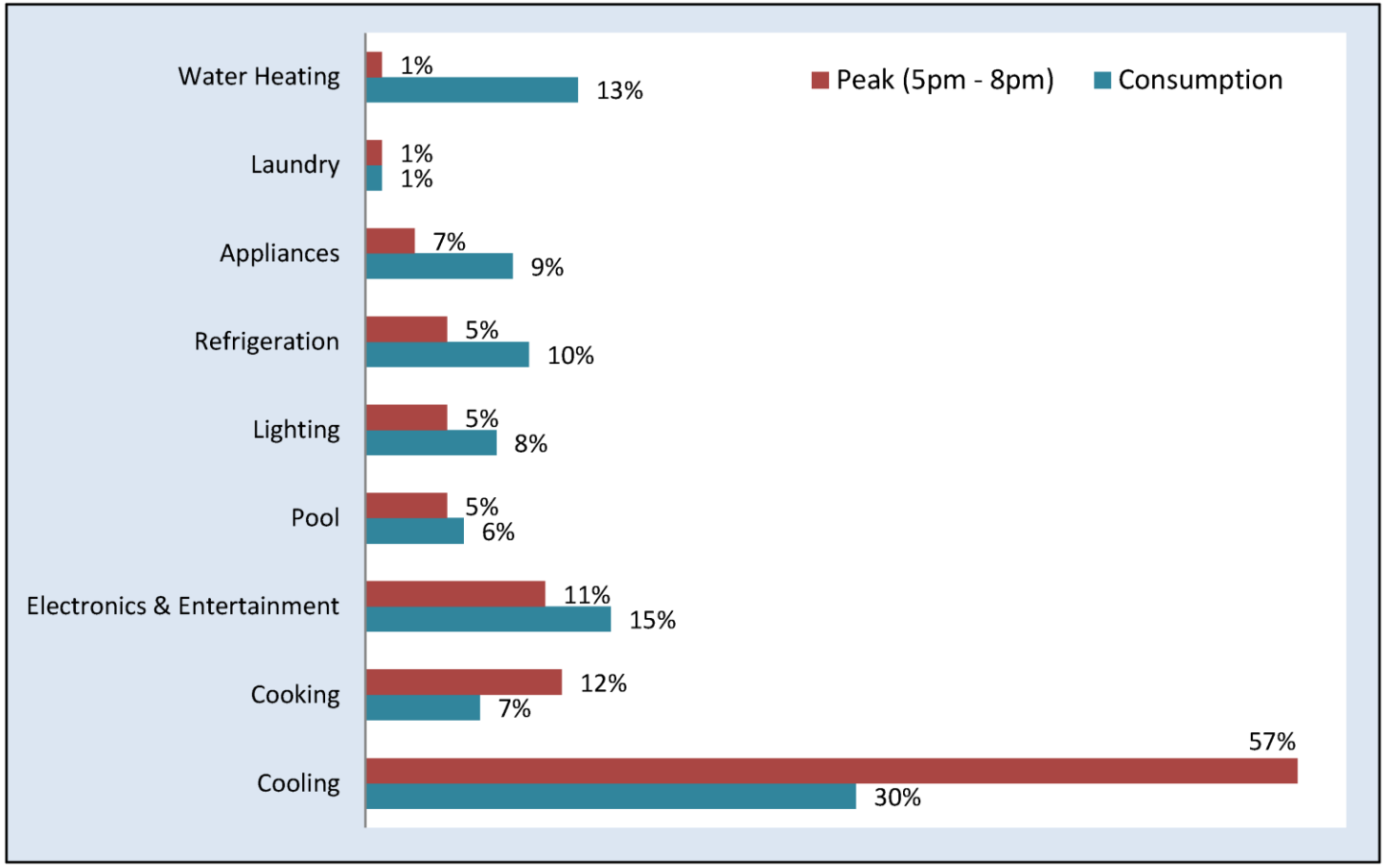
Estimated customer segment contribution – 2025 summer mid-afternoon peak (Ergon Energy)

Residential customer segments



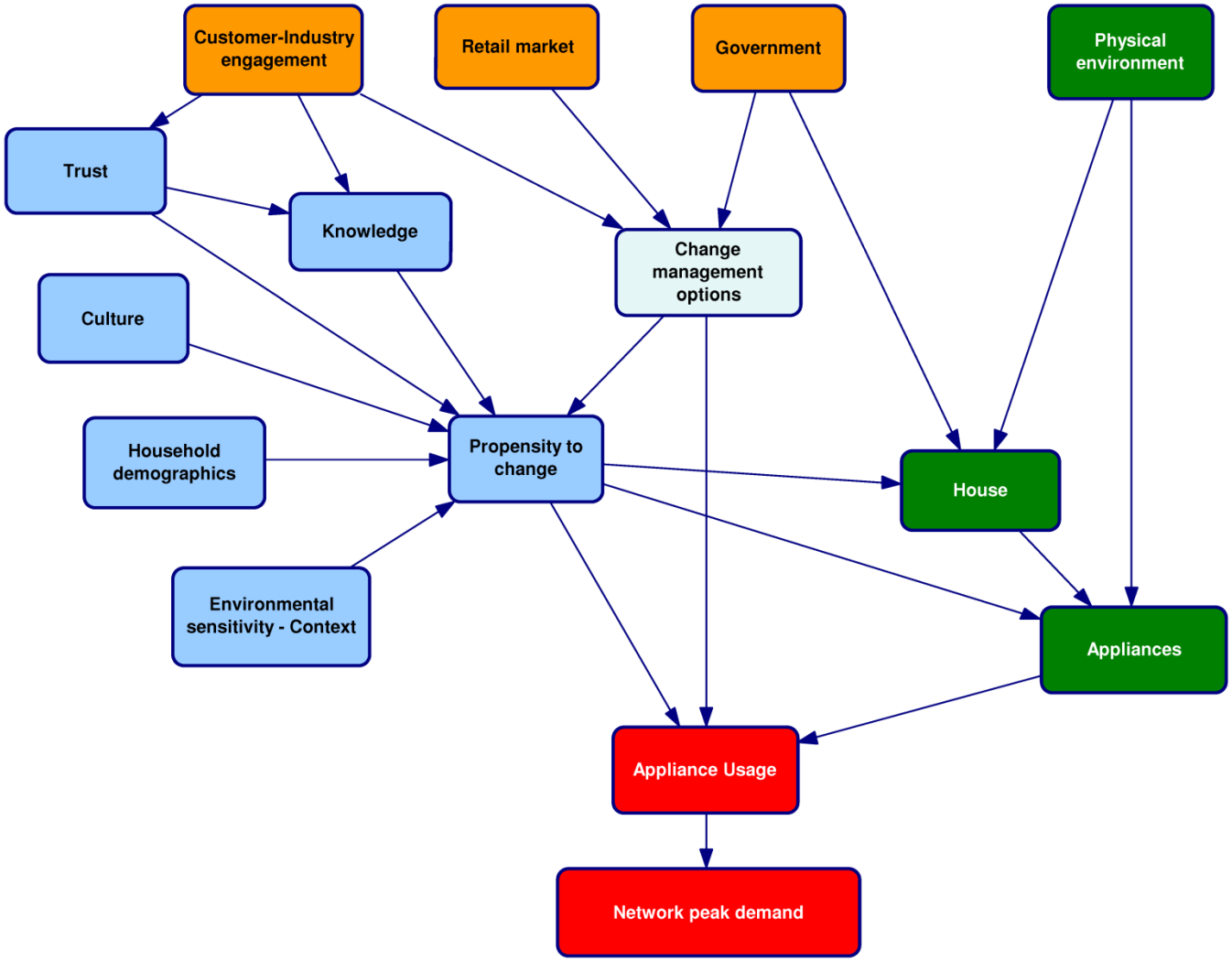
Residential consumption by segments (Ergon Energy)

Appliance use – North Queensland

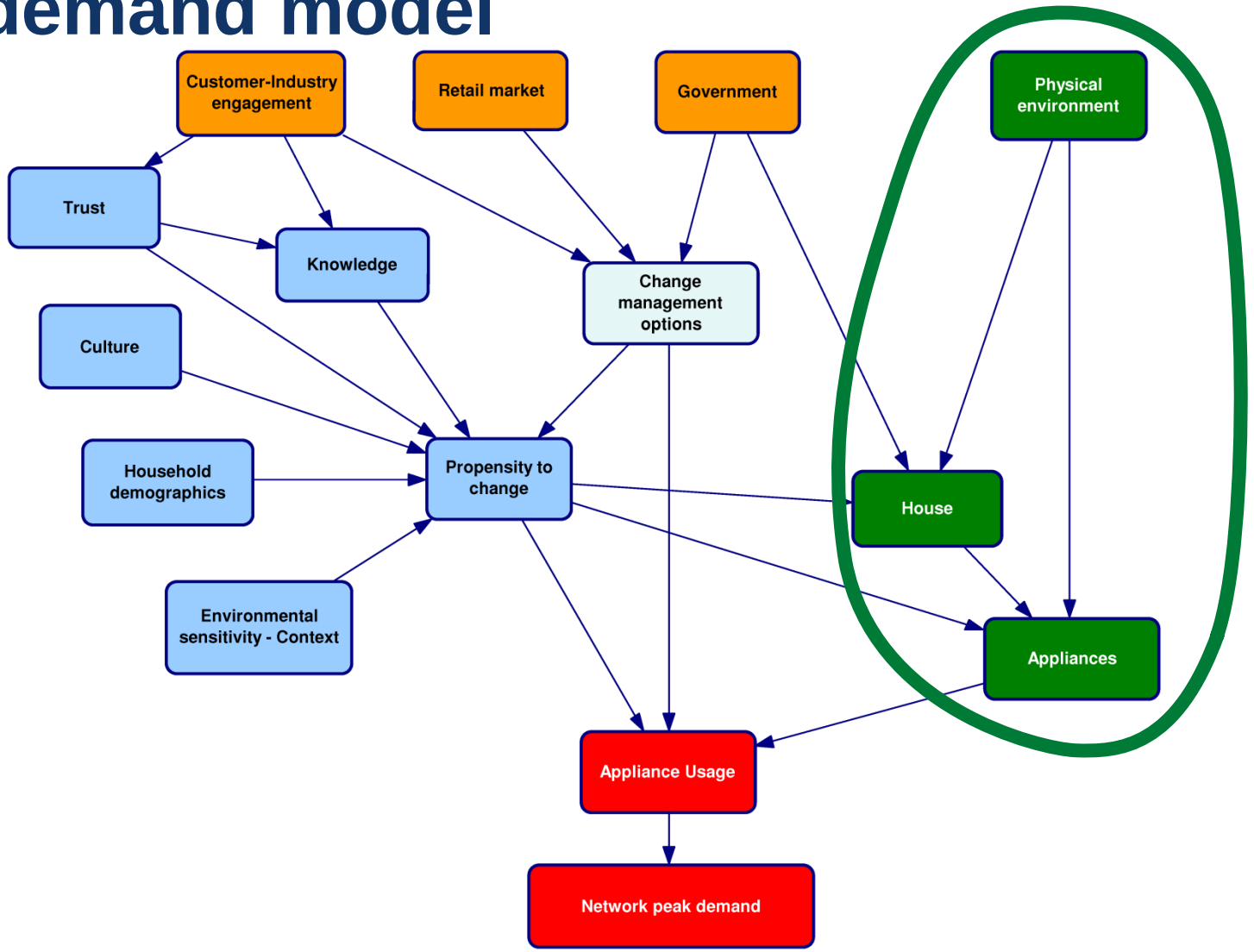


North Queensland average household consumption and demand profile (Ergon Energy)

Residential electricity peak demand model



Residential electricity peak demand model



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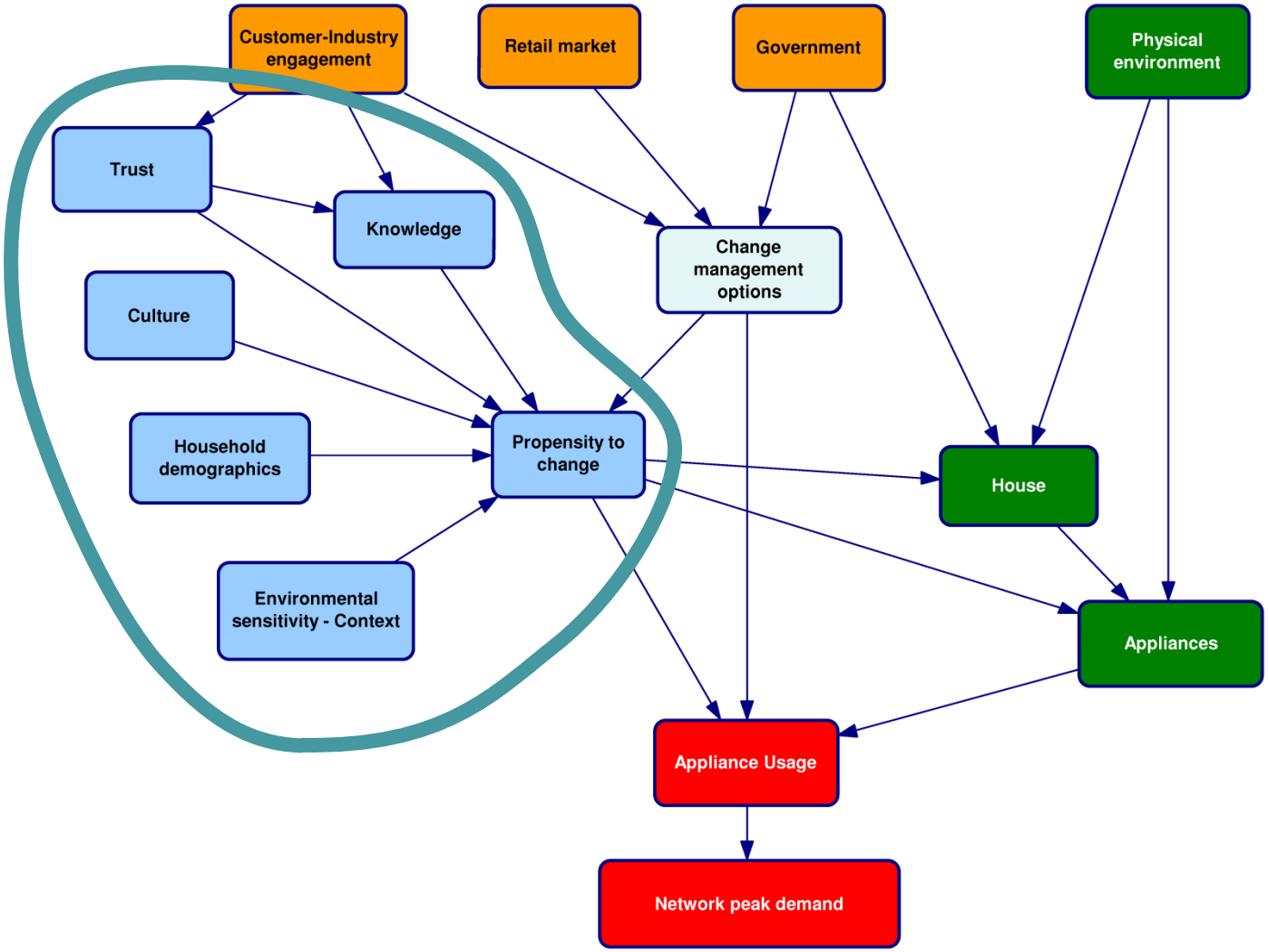

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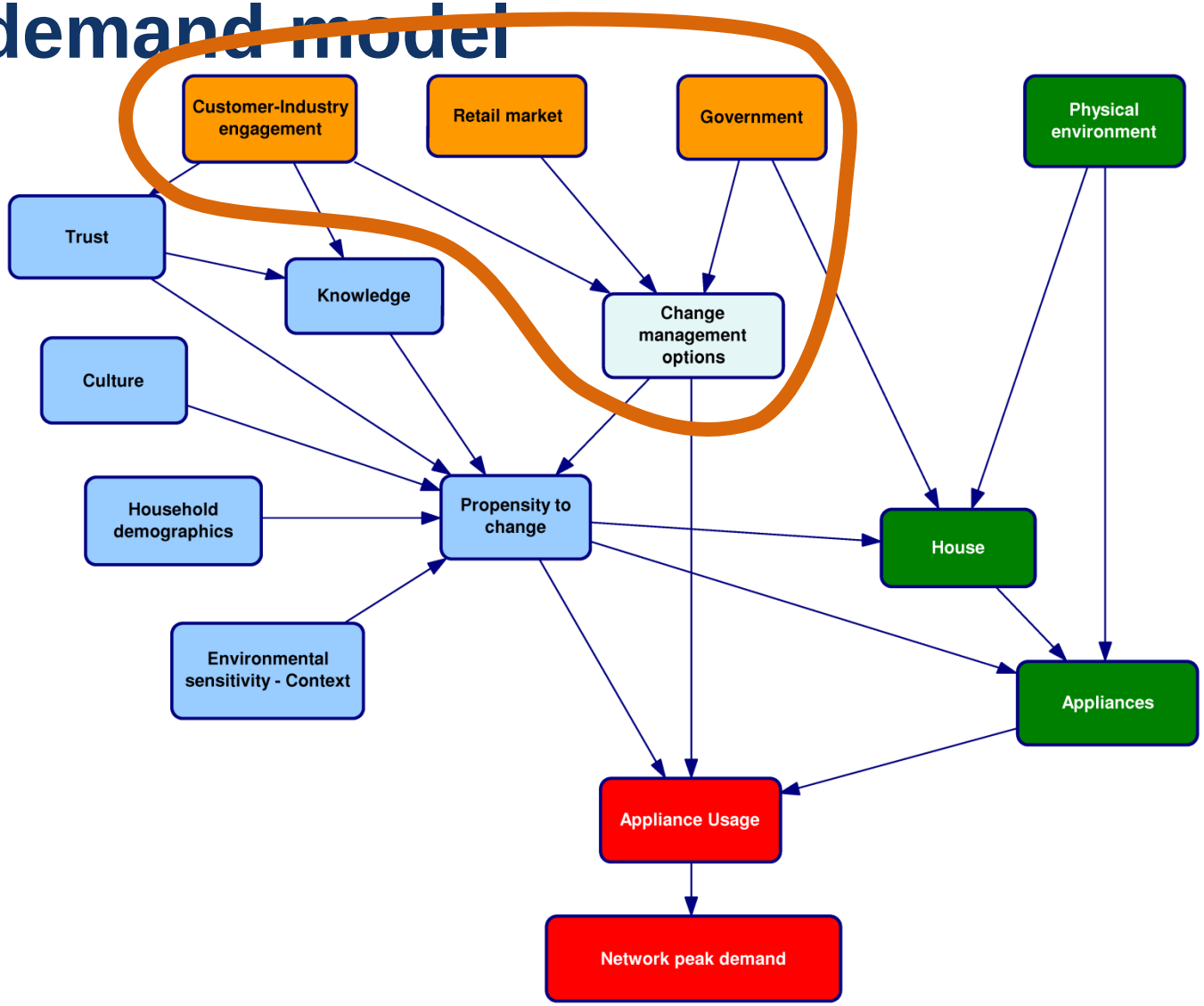
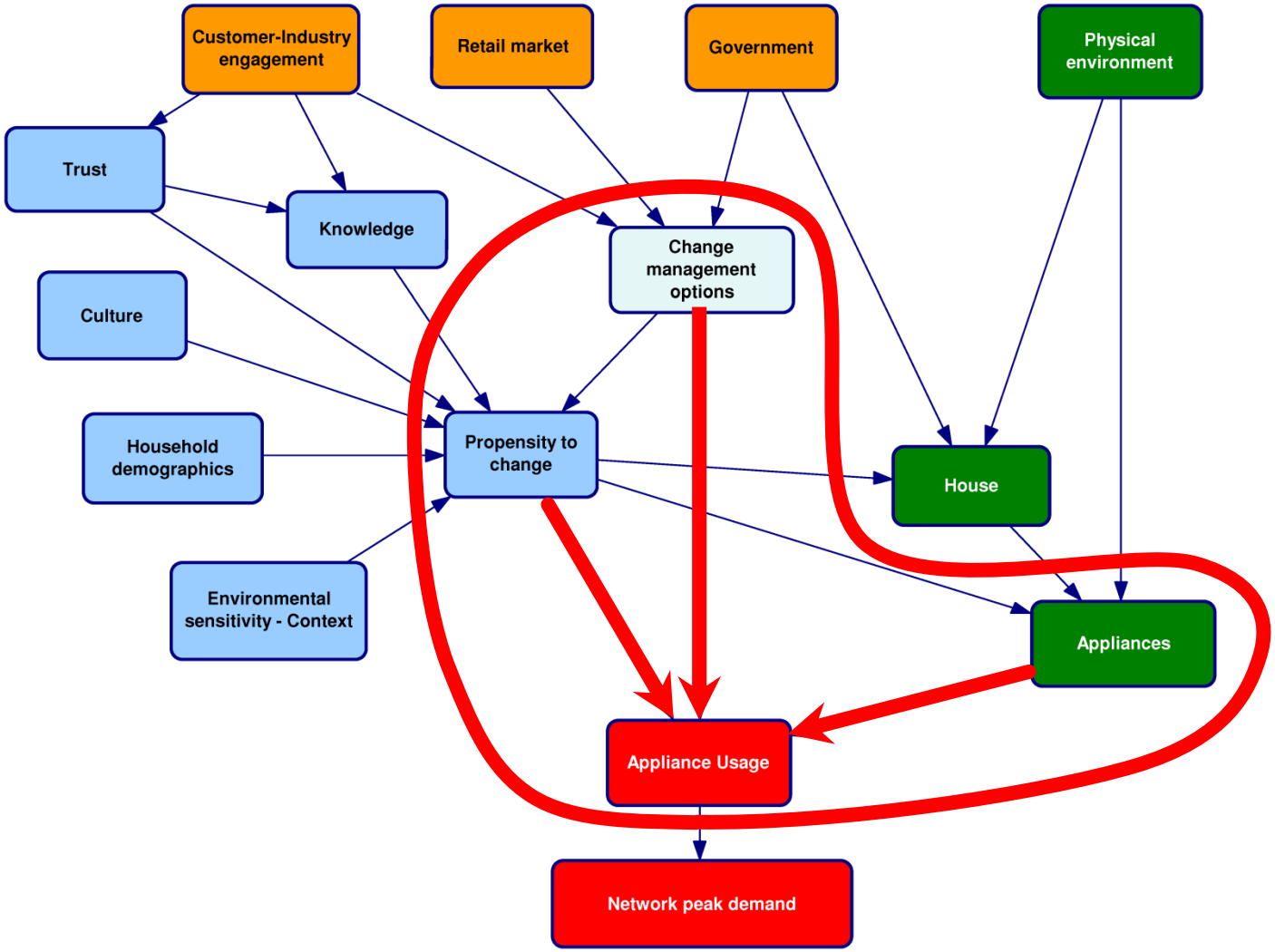


Change management options

- Acknowledgement & recognition
- Time of use tariffs
- Off-peak tariffs and managed supply
- Customer education & engagement
- Price increase
- Appliances (minimum performance standards)
- Capital Spend - Insulation
- Capital Spend - Photovoltaics
- Other strategic intervention

Residential electricity peak demand model



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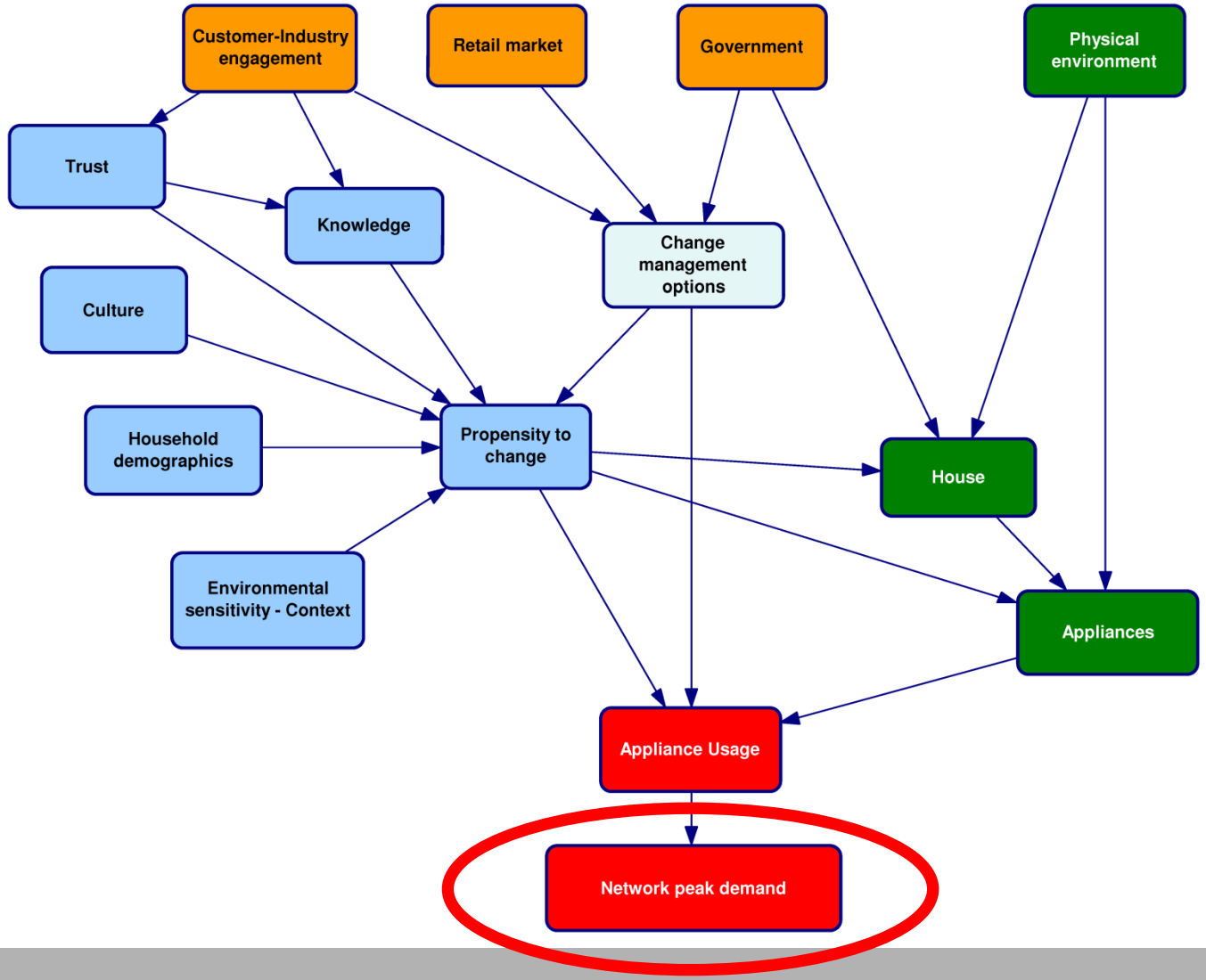
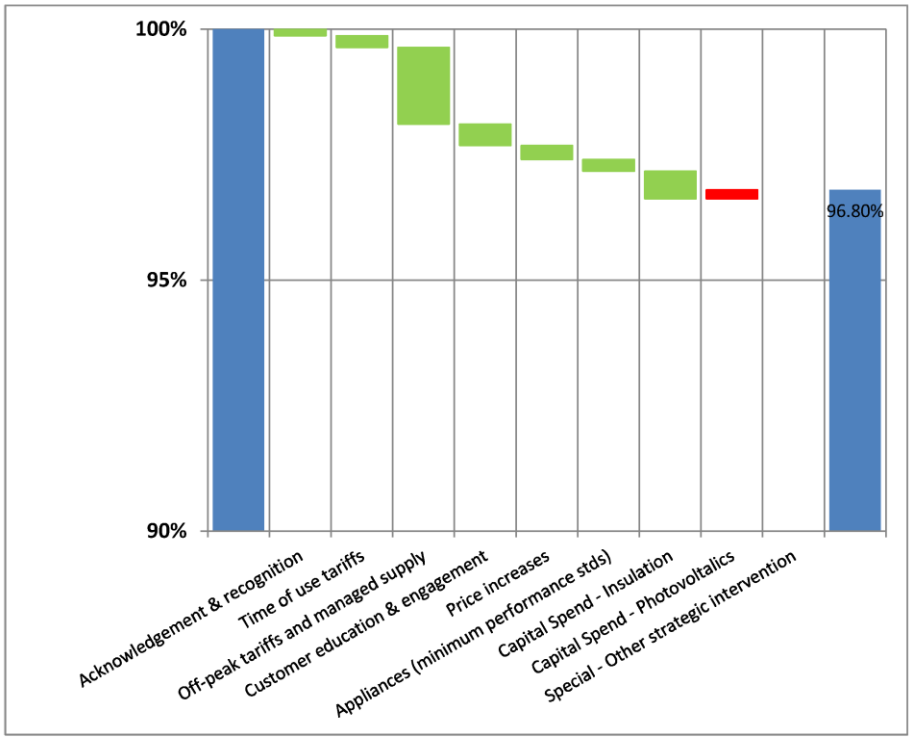


Customer – Industry Engagement

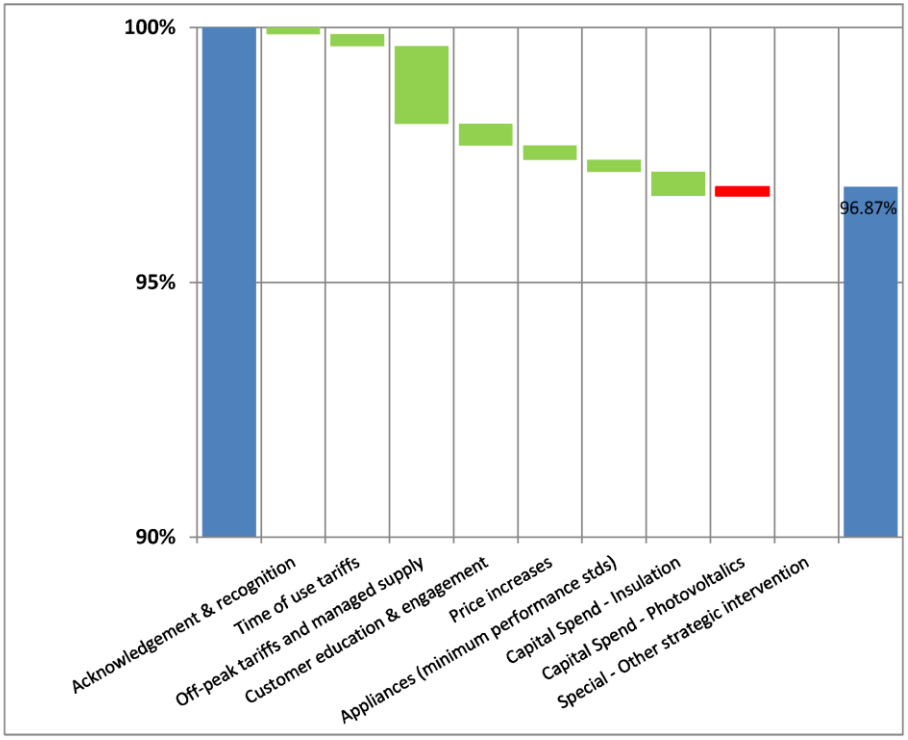
	Education	Engagement
Household (Individual)		
Local community		
Broader community		

Location: Queensland

Summer

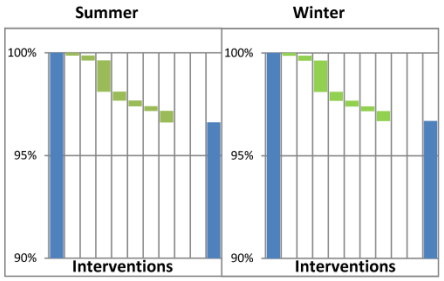


Winter



Location: Queensland

Number of households: 548,000



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Peak energy demand by residential households with and without interventions

	Base rate	With interventions		
	Average diversified demand (MW)	Average diversified demand (MW)	Range (MW)	
Summer	3,026	2,923	2,914	2,933
Percent reduction with interventions		3.38%	3.06% to 3.70%	
Winter	2,615	2,528	2,520	2,536
Percent reduction with interventions		3.31%	3.00% to 3.61%	

The Base rate figures represent the modelled peak demand for the target region for Summer and Winter peak periods with no interventions. The interventions in the system are then modelled response to give the respective anticipated low and high peak demand outcomes for the intervention scenarios.

Set the scenario

Select the location **Queensland** <<=== *Dropdown menu (click on right hand side of cell)*

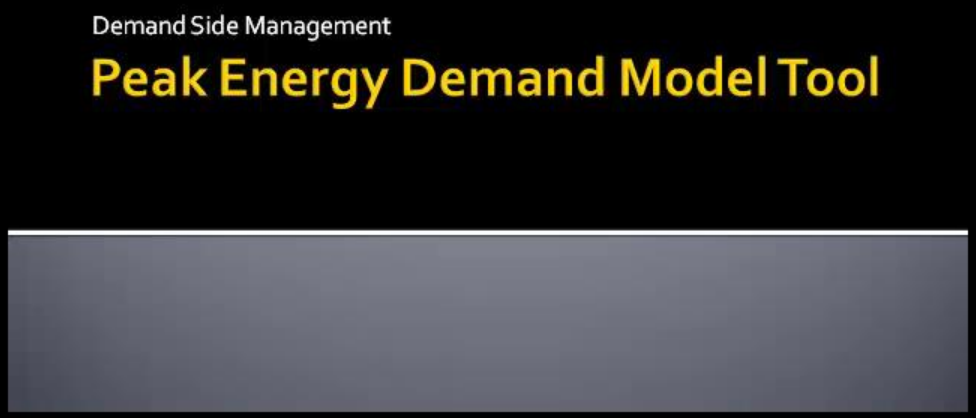
The number of households in Queensland is: 548,000

Interventions

Select intervention for impact on peak demand	Targeting % of consumption* %	Agency implementing the intervention	Change management option (Select) Default is No. Select for Yes	Environmental sensitivity for change. Default is Normal. Select for High	Total change in peak energy demand Summer -3.38%	Winter -3.31%
CMO - Acknowledgement & recognition	21.3	Retail	☑ Yes	☐ Normal	-0.13%	
CMO - Time of use tariffs	3.3	Retail or Govt	☑ Yes	☐ Normal	-0.24%	
CMO - Off-peak tariffs and managed supply	57.7	Retail	☑ Yes	☐ Normal	-1.53%	
CMO - Customer education & engagement	72.3	Retail or Govt	*Select using the table below*		-0.42%	
CMO - Price increase	100.0	Govt	☑ Yes	☐ Normal	-0.28%	
CMO - Appliances (minimum performance standards)	23.3	Govt	☑ Yes	☐ Normal	-0.23%	
					Summer	Winter
CMO - Capital Spend - Insulation	48.4	Retail or Govt	☑ Yes	☐ Normal	-0.55%	-0.48%
CMO - Capital Spend - Photovoltaics	33.9	Retail or Govt	☐ No	☐		
CMO - Other strategic intervention - (Read this) Special (To enable examination of other options).	0.0	Retail or Govt	☐ No	☐		

Customer-Industry Engagement

Demand side management



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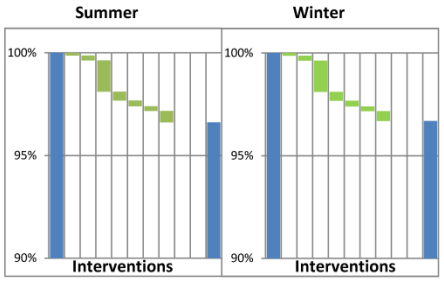
Number of households: 548,000



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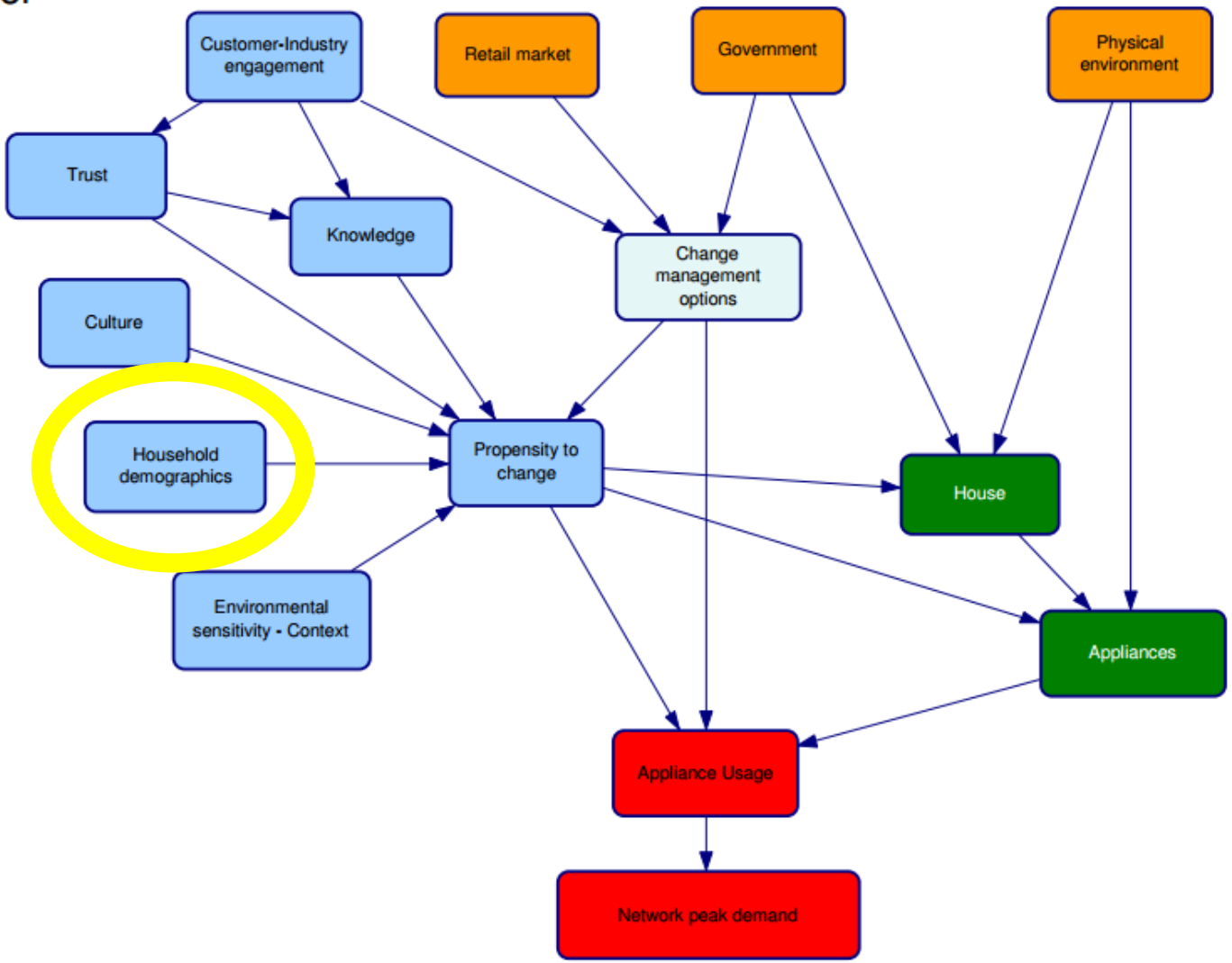
Customer-Industry Engagement

Residential electricity network peak demand model



Electricity consumption by household profile

For Queensland

(with different percentages for the other centres being modelled.)

	A	B	C	D	E	F	G	H	I
1	**Household** (residential segment profile and consumption characteristics for the current scenario)								
2	To Contents page								
3	Main page								
4	Household Segments Consumption Bands are defined by the **% of total electricity consumption.**								
5	The categories of High, Medium and Low consumption are not used in the model. The % of total electricity consumption for each individual segment is used.								
6	Propensity to Change is based Segment Profile by Change Management Option								
7									
8	***This table is for the current selected location --Queensland-- from the data entered into the respective table below.***								
9	**Segment Consumption Band**	**Residential Segment profile**	% of total consumption	*Segments ordered per Ergon Energy (2012) report*					
10	**High**	'Cash & Careers'	5.1%		20.6%				
11		'Transition Blues'	4.1%						
12		'Gen X Parents'	5.3%						
13		'Flush Families'	6.2%						
14	**Medium**	'Beginnings'	12.3%		58.1%				
15		'Taking Hold'	7.1%						
16		'Gen X Singles'	7.5%						
17		'Boomer Barons'	4.3%						
18		'Modest Means'	21.9%						
19		'Mature Wealth'	5.0%						
20	**Low**	'Golden Years'	3.3%		21.3%				
21		'Active Elders'	8.3%						
22		'Leisure Buffs'	6.9%						
23		'Our Turn'	2.8%						
24									

Customer segment clusters

Percent energy consumption for cluster

Customer segment clusters for strategic interventions	Percent electricity consumption by Centre			
	Queensland	Toowoomba	Townsville	Mackay
1. • Customer Education and Engagement	72.3%	72.9%	74.3%	73.5%
2. • Off-peak tariffs and managed supply	57.7%	60.9%	52.7%	53.9%
3. • Capital Spend – Insulation	48.4%	45.5%	48.7%	49.0%

Customer segment clusters

Percent energy consumption for cluster

Customer segment clusters for strategic interventions	Percent electricity consumption by Centre			
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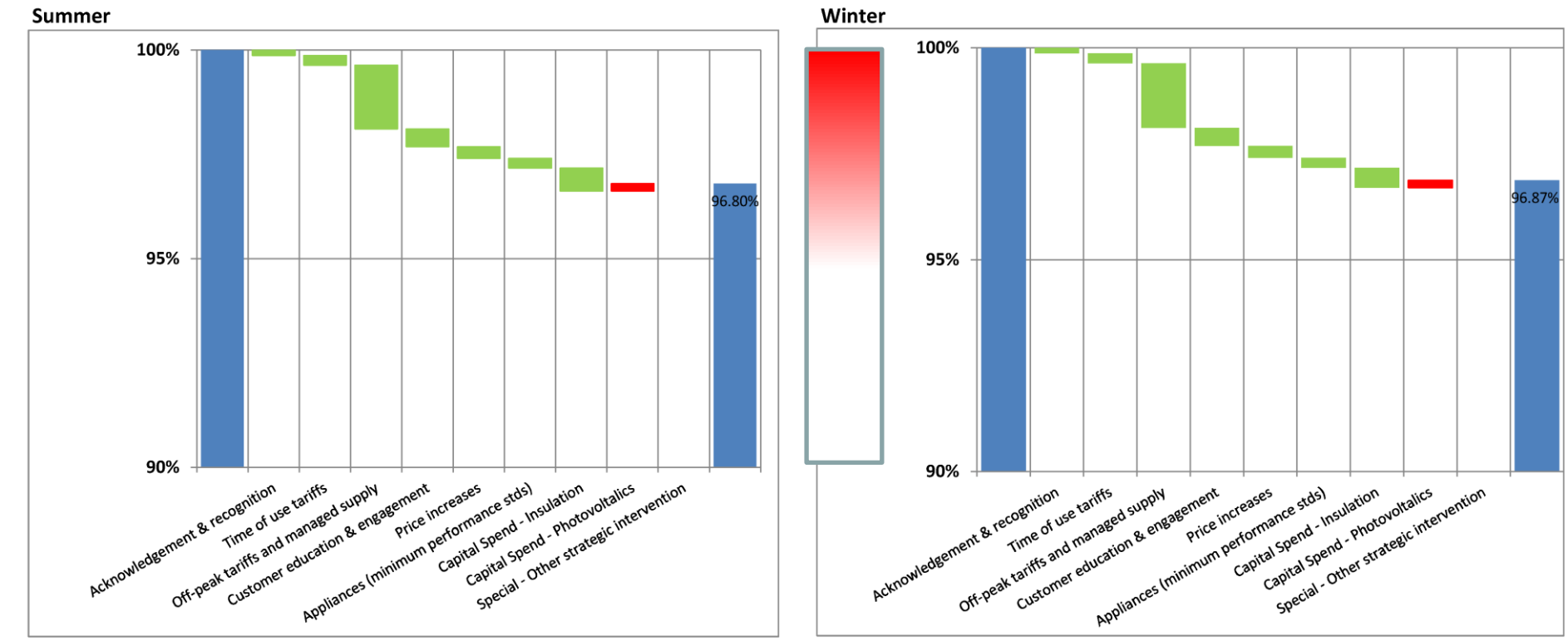
1. • Customer Education and Engagement	72.3%	72.9%	74.3%	73.5%
2. • Off-peak tariffs and managed supply	57.7%	60.9%	52.7%	53.9%
3. • Capital Spend – Insulation	48.4%	45.5%	48.7%	49.0%

Impact for scenario

Location: Queensland



Scenarios

	CMO applied (ticked - selected)	Impact on network peak demand	
Acknowledgement & recognition	✓	-0.24%	
Time of use tariffs	✓	-0.24%	
Off-peak tariffs and managed supply	✓	-2.37%	
Customer education and engagement	✓	-0.75%	
Price increase	✓	-0.28%	
Appliances (min. performance standards)	✓	-0.23%	
Capital Spend - Insulation	✓	Summer -0.90%	Winter -0.75%

Network peak demand (MW) for residential households

Region: Queensland

Number of households: 548,000

Network peak demand for residential households

Diversified demand	Base rate (MW)	
Summer	3,026	MW
Winter	2,615	MW

Network peak demand for residential households with

Diversified demand	Peak demand (MW)	Range		
Summer	2,874	2,859	2,890	MW
Reduction (%)	5.01%	4.50% to 5.52%		
Winter	2,483	2,475	2,500	MW
Reduction (%)	4.86%	4.38% to 5.34%		

Percentage of customers' consumption already in each state	Acknowledgement & recognition	Time of use tariffs	Off-peak tariffs and managed supply	Price increases	Appliances (Min. performance standards)	Capital spend - Insulation.	Capital spend Photovoltaics	Customer education & engagement
High	5.0%	0.5%	15.0%	1.0%	0.0%	2.0%	0.1%	0.0%
Low	5.0%	0.5%	15.0%	1.0%	0.0%	10.0%	1.0%	0.0%

Queensland, Townsville and Toowoomba. Reductions in network peak demand.

Change management options	Brisbane		Townsville		Toowoomba	
	Summer	Winter	Summer	Winter	Summer	Winter
Total change	**-3.20%**	**-3.13%**	**-3.47%**	**-2.57%**	**-3.11%**	**-3.51%**
Acknowledgement & recognition	-0.13%		-0.11%		-0.15%	
Time of use tariffs	-0.24%		-0.21%		-0.20%	
Off-peak tariffs and managed supply	-1.53%		-1.31%		-1.66%	
Customer education & engagement	-0.42%		-0.43%		-0.43%	
Price increase	-0.28%		-0.28%		-0.28%	
Appliances (minimum performance standards)	-0.23%		-0.24%		-0.20%	
	Summer	Winter	Summer	Winter	Summer	Winter
Capital Spend - Insulation	-0.55%	-0.48%	-1.07%	-0.17%	-1.52%	-0.25%
Capital Spend - Photovoltaics	0.18%		0.18%		0.18%	

Residential electricity peak demand model