Modelling the Residential Consumer: Electricity Demand & Price Response

Killian McKenna, PhD Student, ERC, EI, UCD
Pádraig Daly, Dr Lisa Ryan, Dr Andrew Keane

funding acknowledgement

DEMAND SIDE MANAGEMENT

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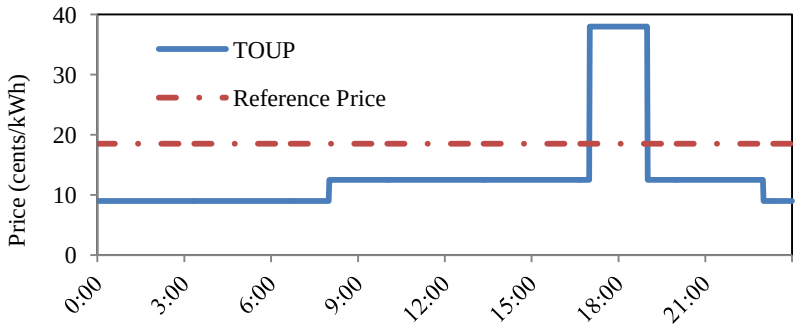
DYNAMIC RETAIL PRICING



DEMAND SIDE MANAGEMENT

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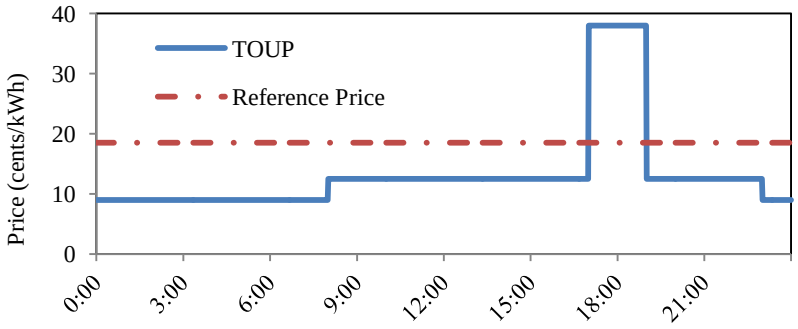
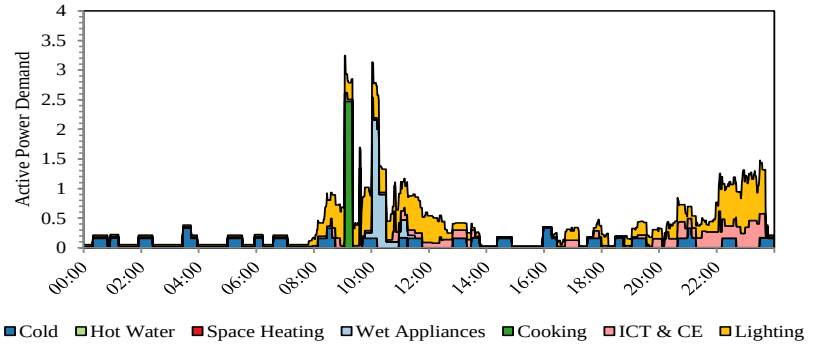


RESIDENTIAL MODELLING



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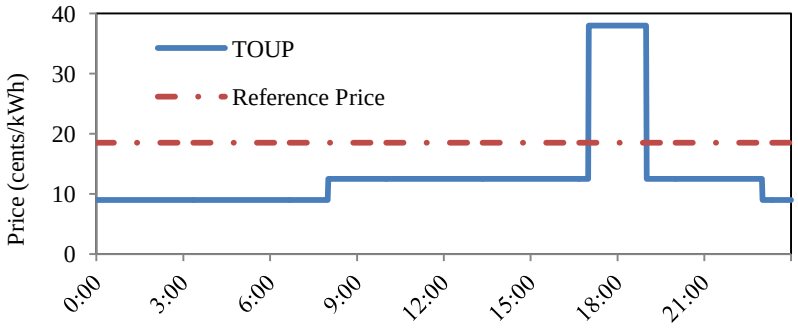

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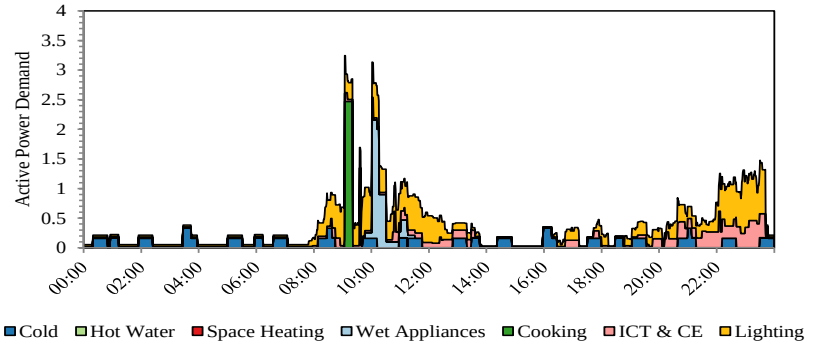
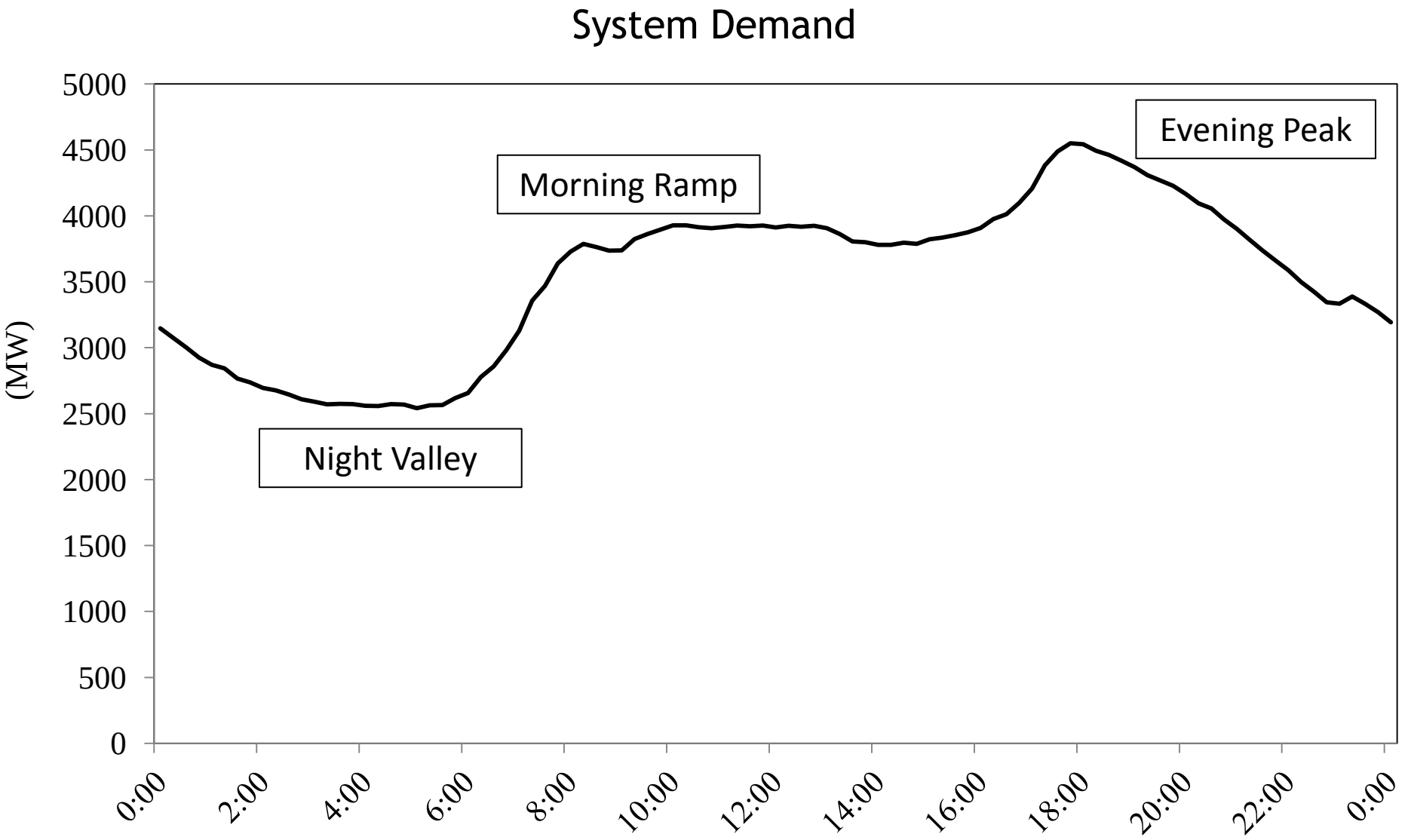


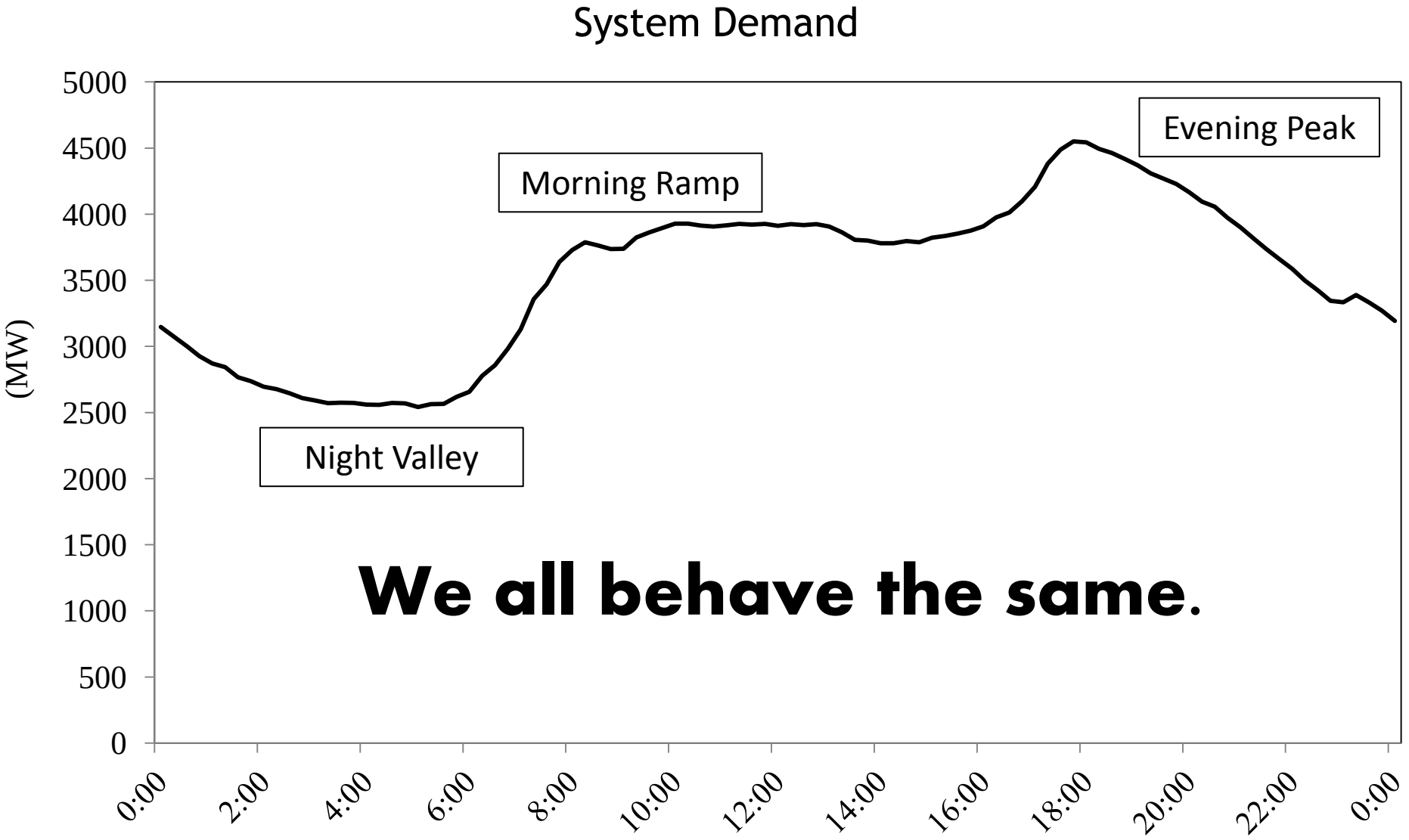
MODELLING RESIDENTIAL PRICE RESPONSE

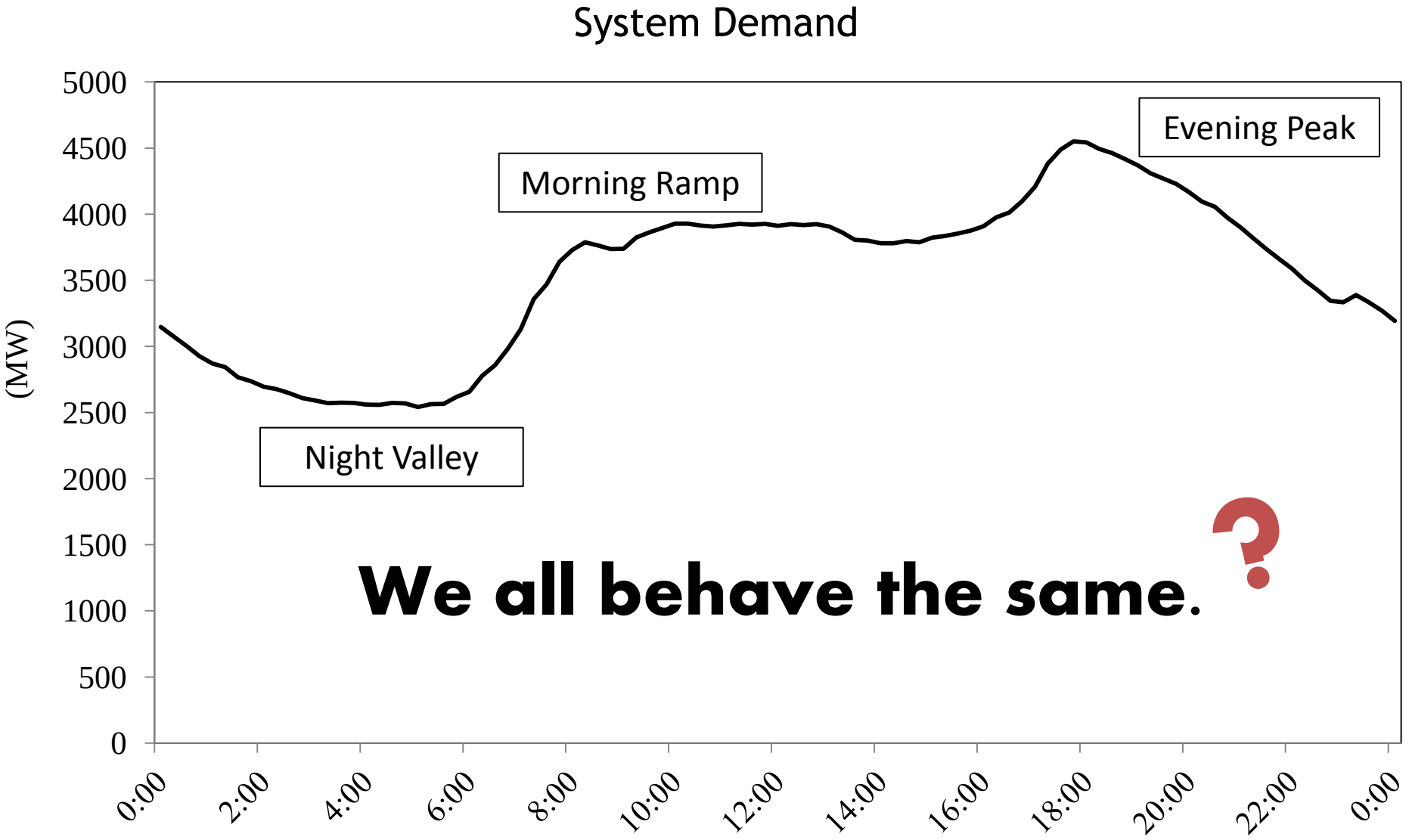
ASSESSING THE IMPACT:

DISTRIBUTION NETWORKS ~ SYSTEM WIDE ANALYSIS

Demand Modelling & Characteristics


System Demand
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
(MW)
Evening Peak
Morning Ramp
Night Valley
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


System Demand
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
(MW)
Evening Peak
Morning Ramp
Night Valley
We all behave the same.
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00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5000
4500
4000
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0
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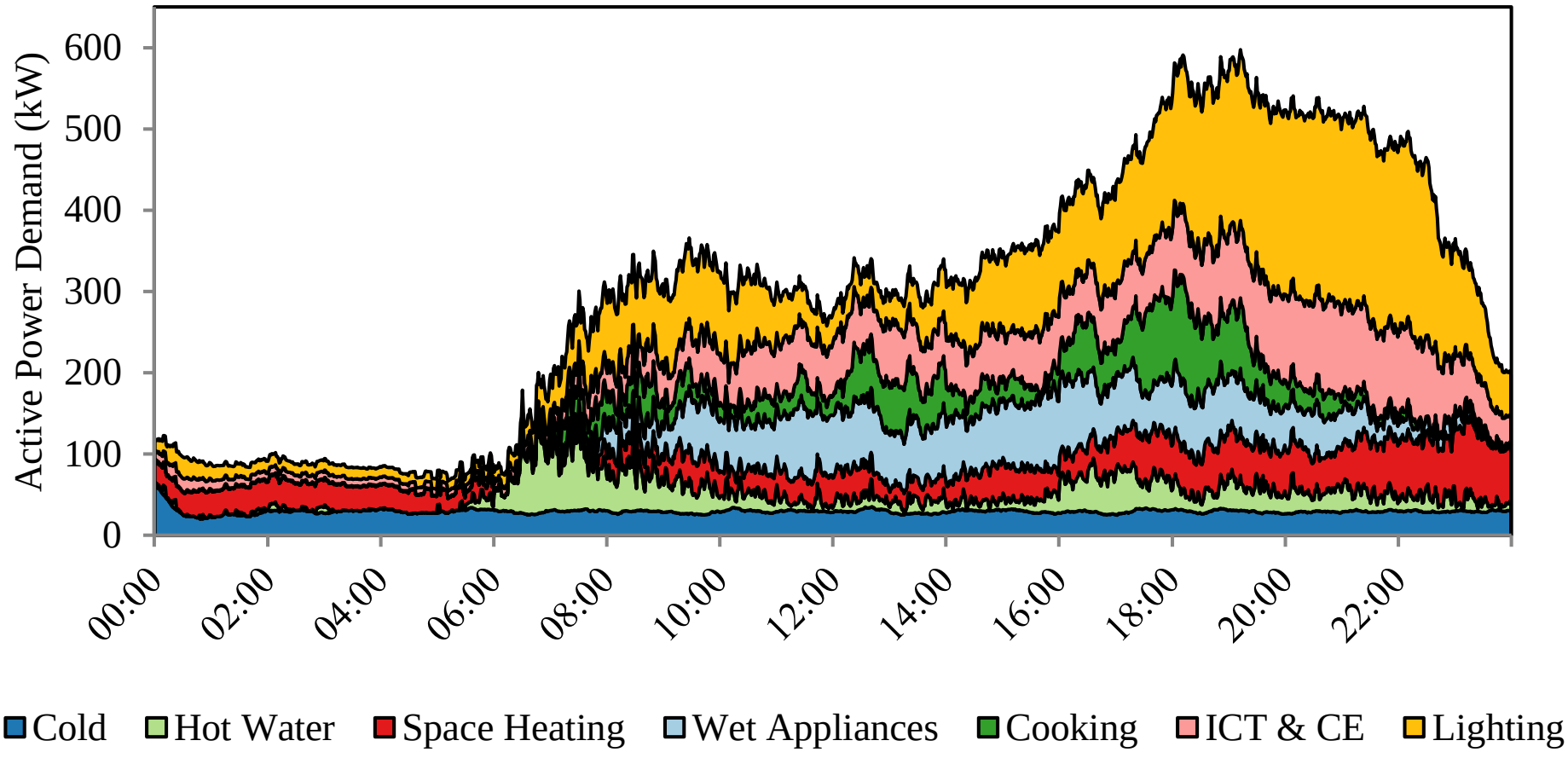
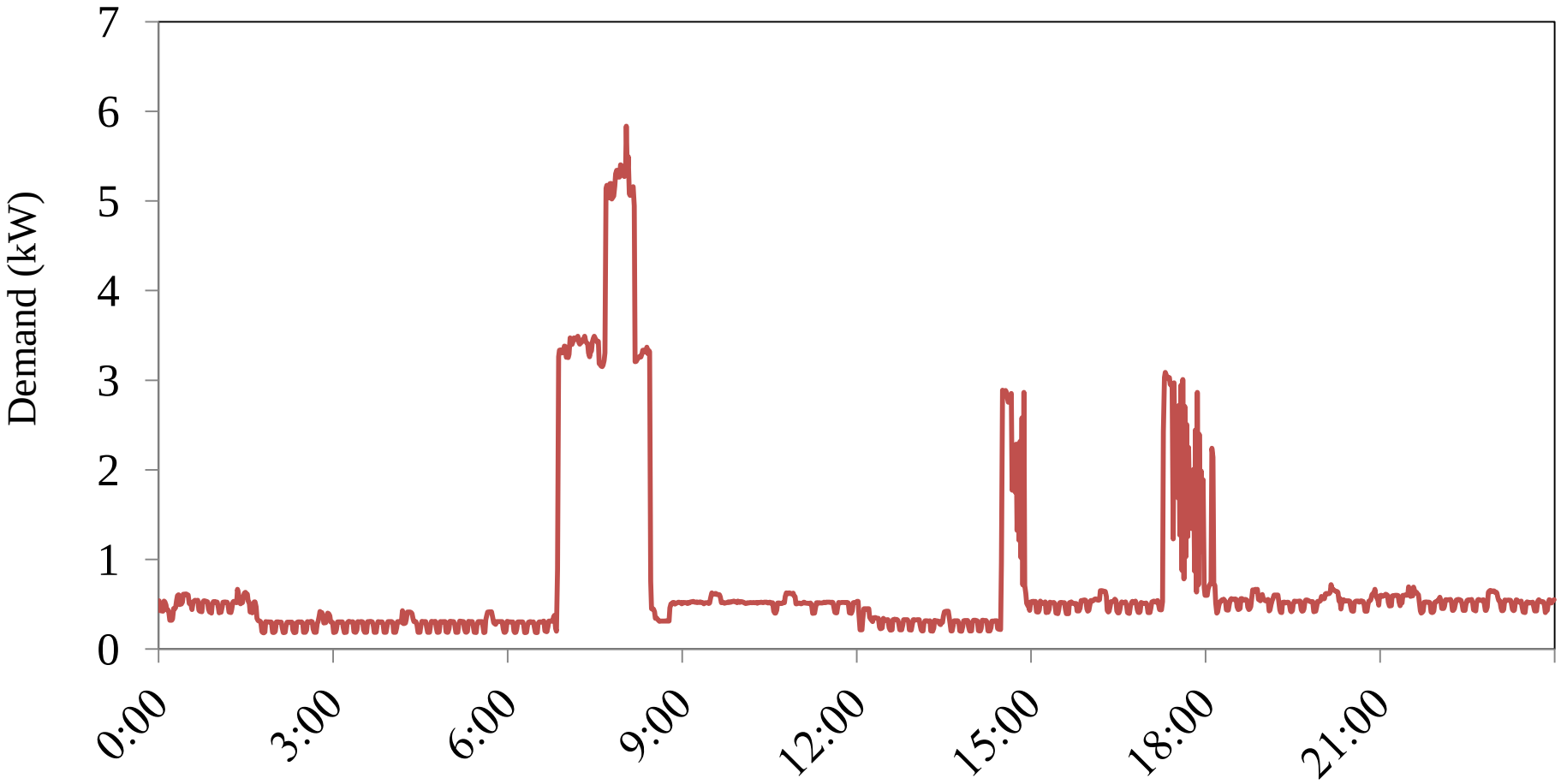
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Night Valley
Morning Ramp
Evening Peak
We all behave the same.
?

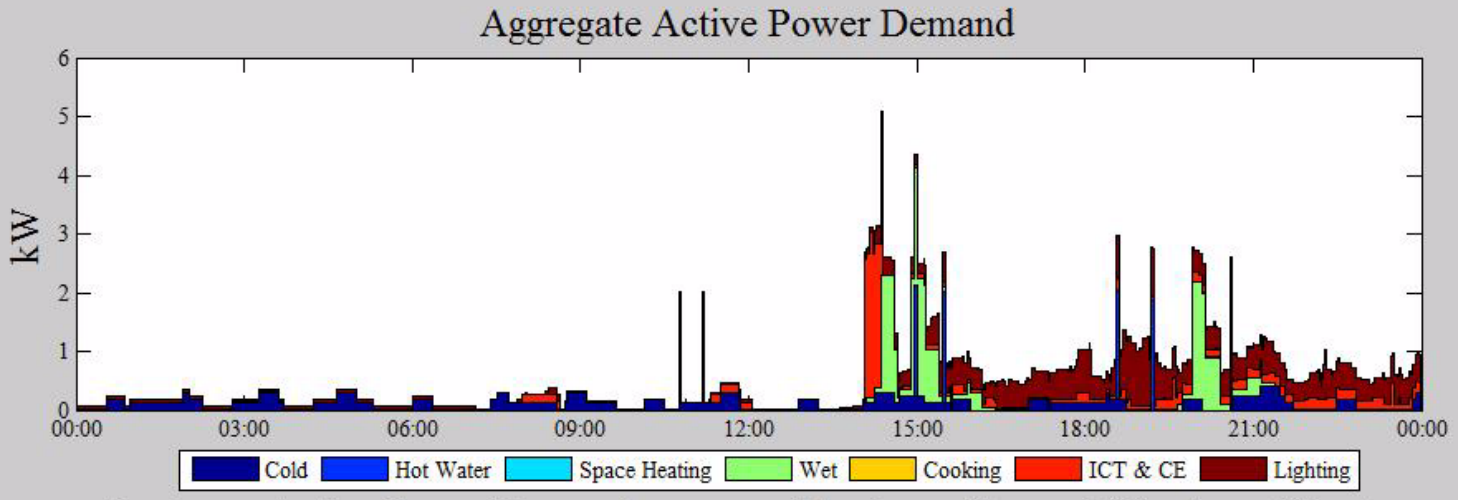
Electricity Demand: 500 Houses

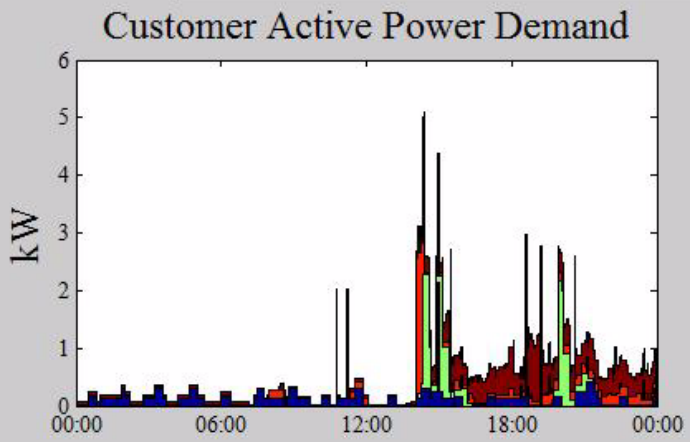


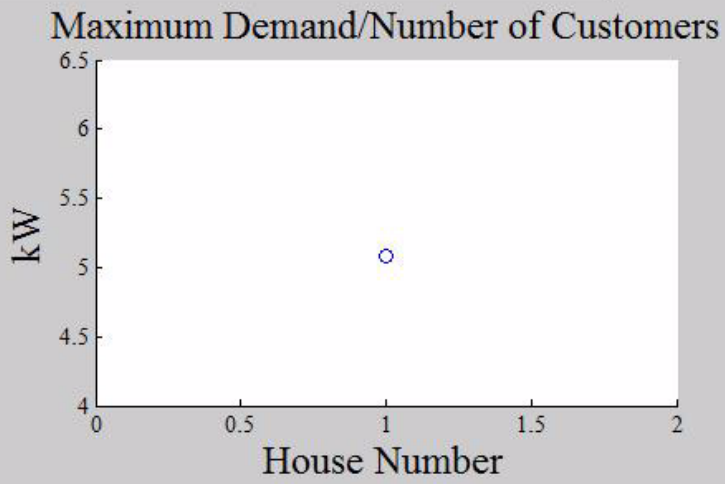
Electricity Demand: 1 House



Modelling Behaviour...

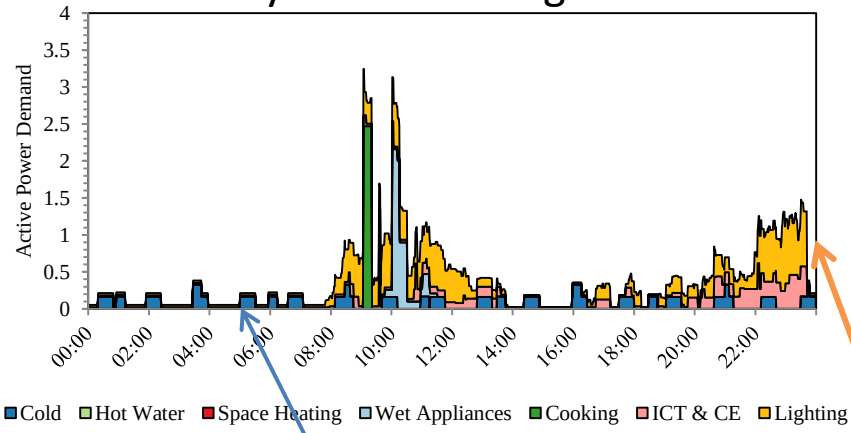




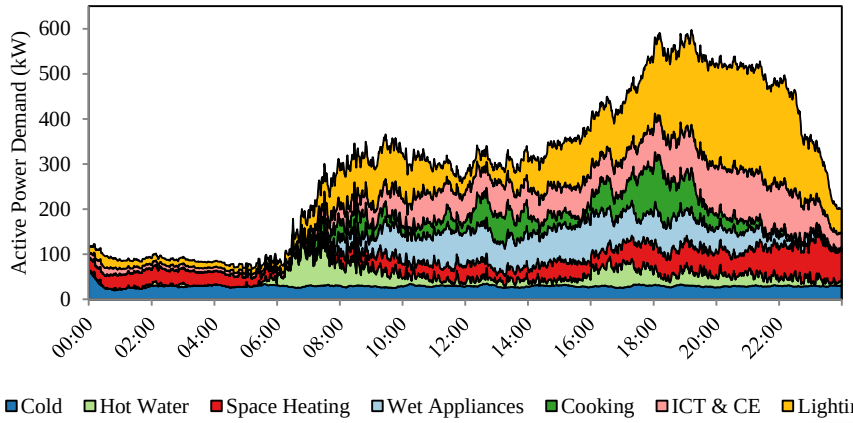


Modelling the Residential Consumer: Electricity Demand & Price Response

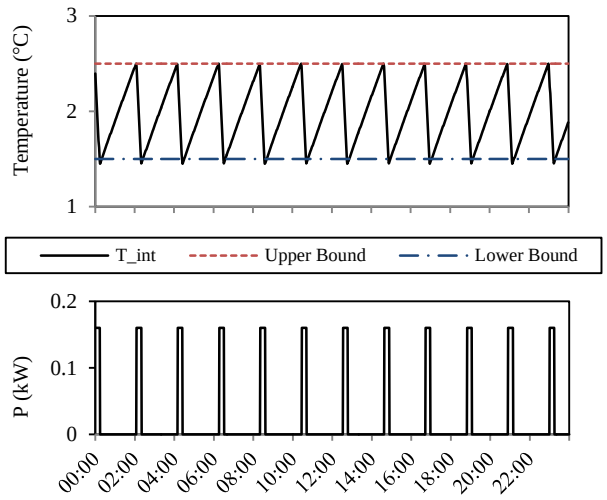
Electricity Demand: Single House



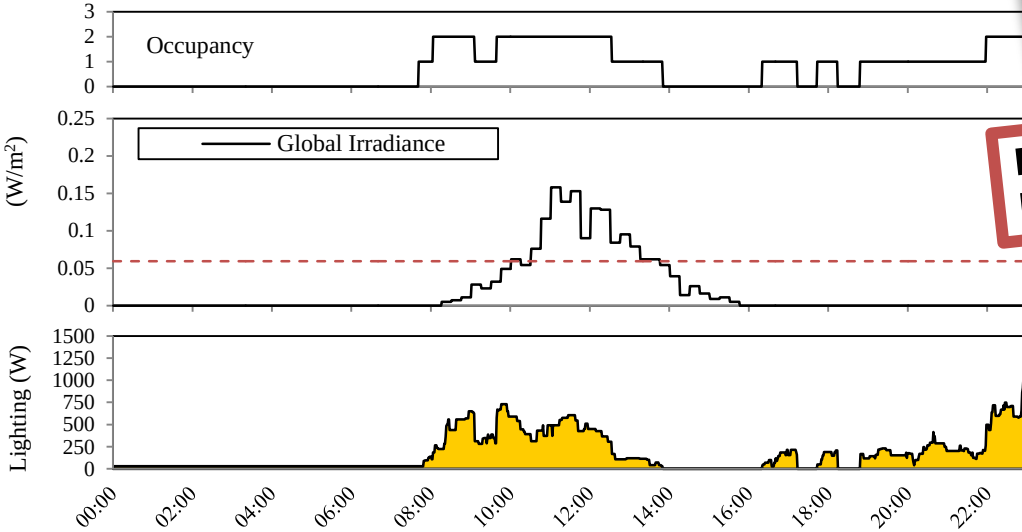
Electricity Demand: 500 Houses



Domestic Fridge

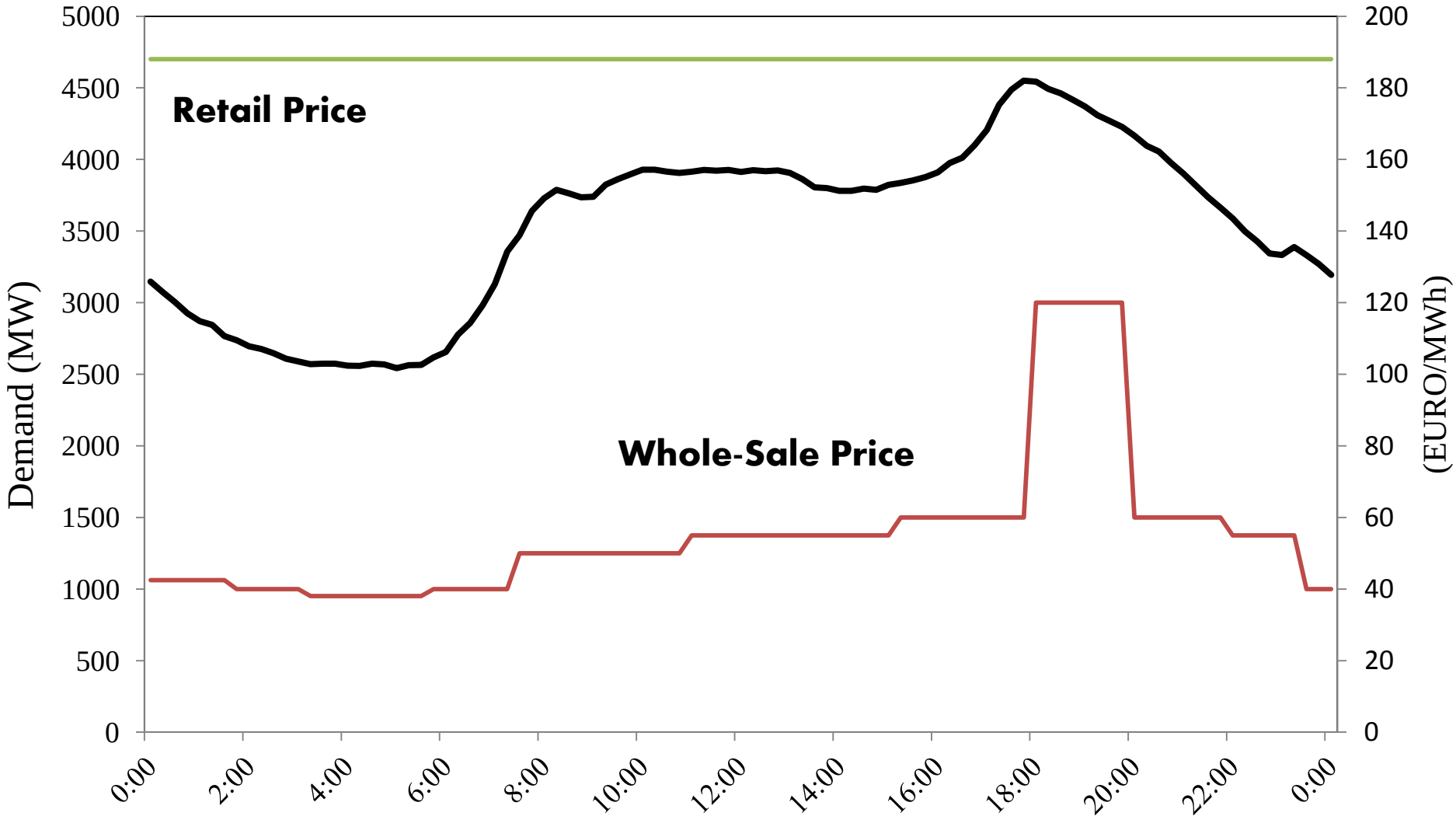


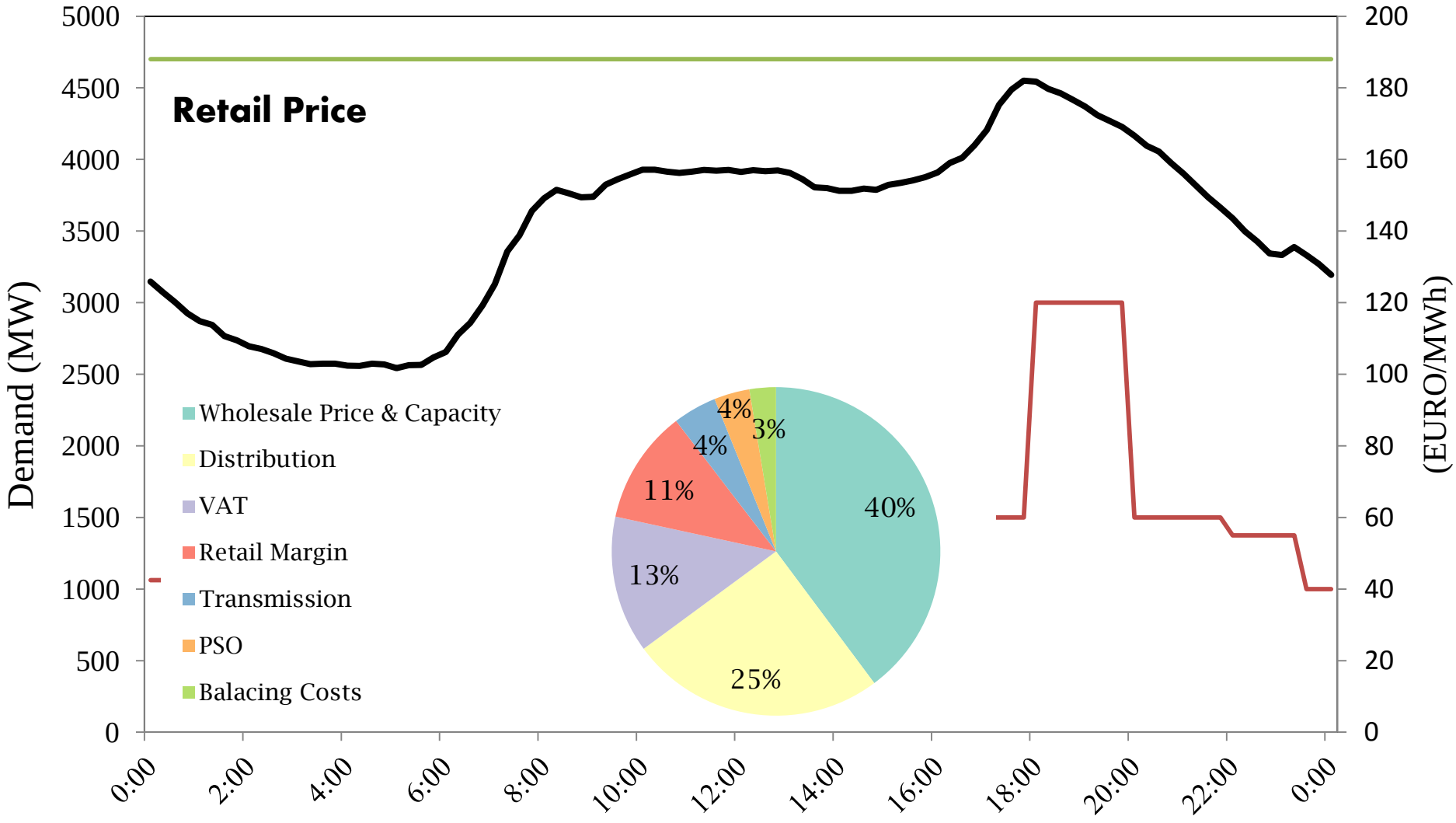
Domestic Lighting – Per Bulb Basis



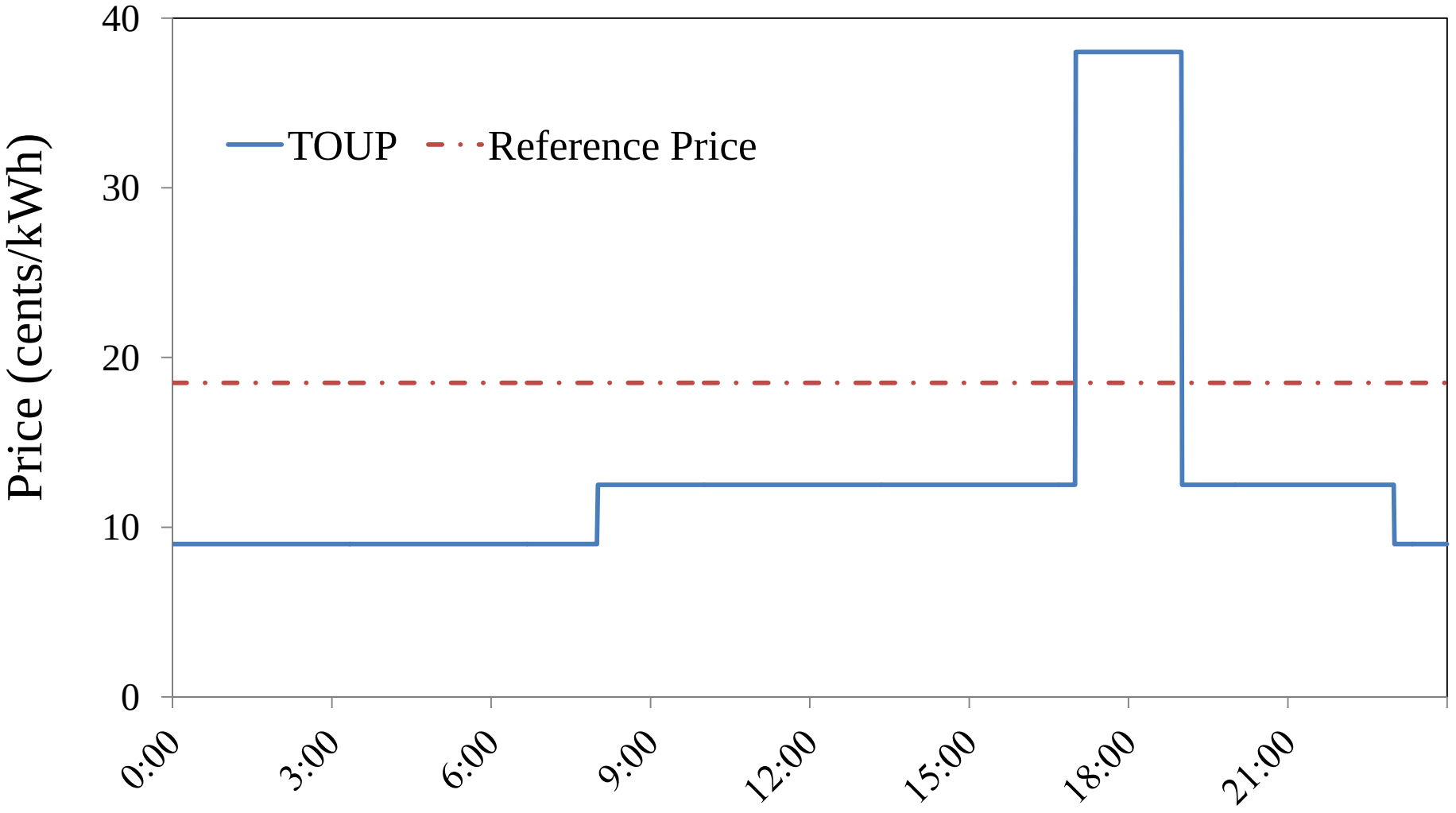
INPUT DATA

Dynamic Retail Pricing


Retail Price
Whole-Sale Price
Demand (MW)
(EURO/MWh)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
200
180
160
140
120
100
80
60
40
20
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Retail Price
Demand (MW)
(EURO/MWh)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
200
180
160
140
120
100
80
60
40
20
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Wholesale Price & Capacity
Distribution
VAT
Retail Margin
Transmission
PSO
Balacing Costs
40%
25%
13%
11%
4%
4%
3%

Time-of-Use Pricing (TOUP)



Models vs real life trials?

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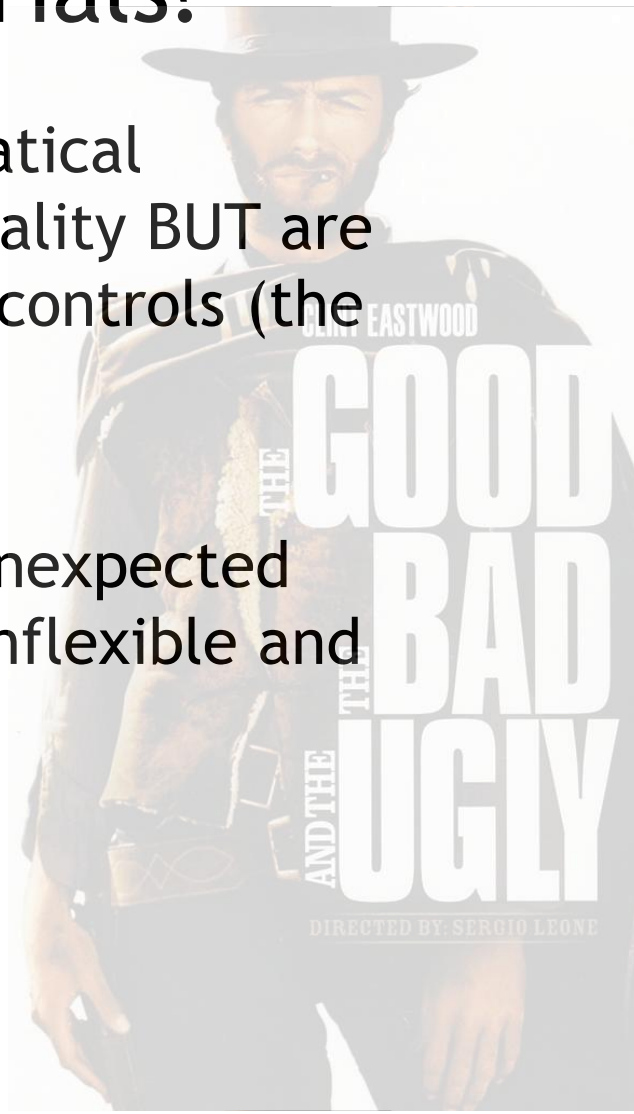

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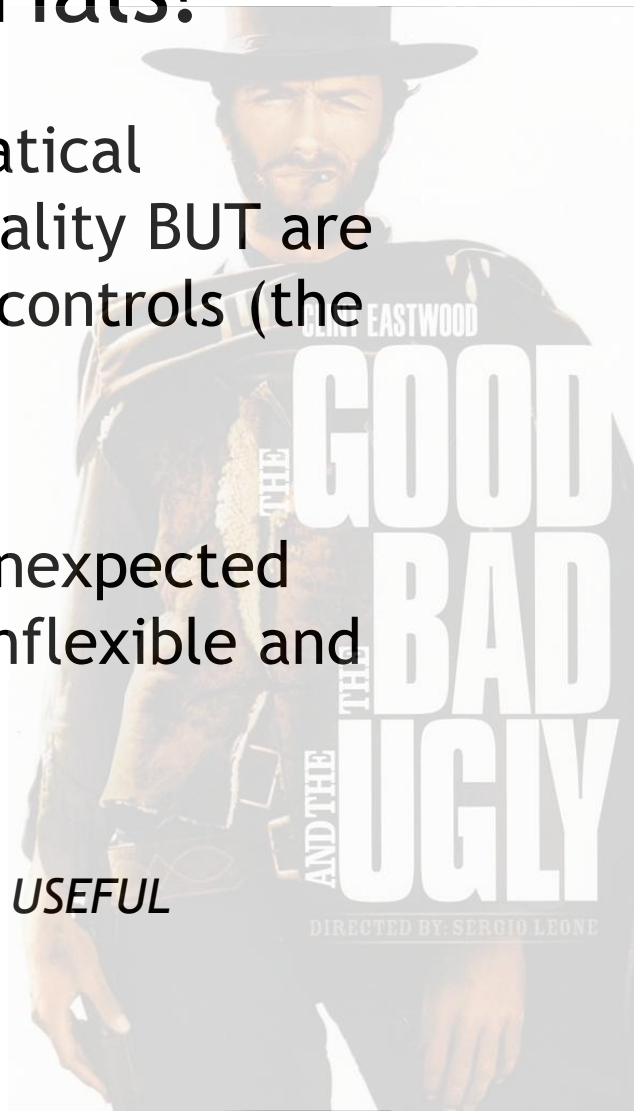
NEITHER ARE PERFECT, BUT BOTH ARE USEFUL



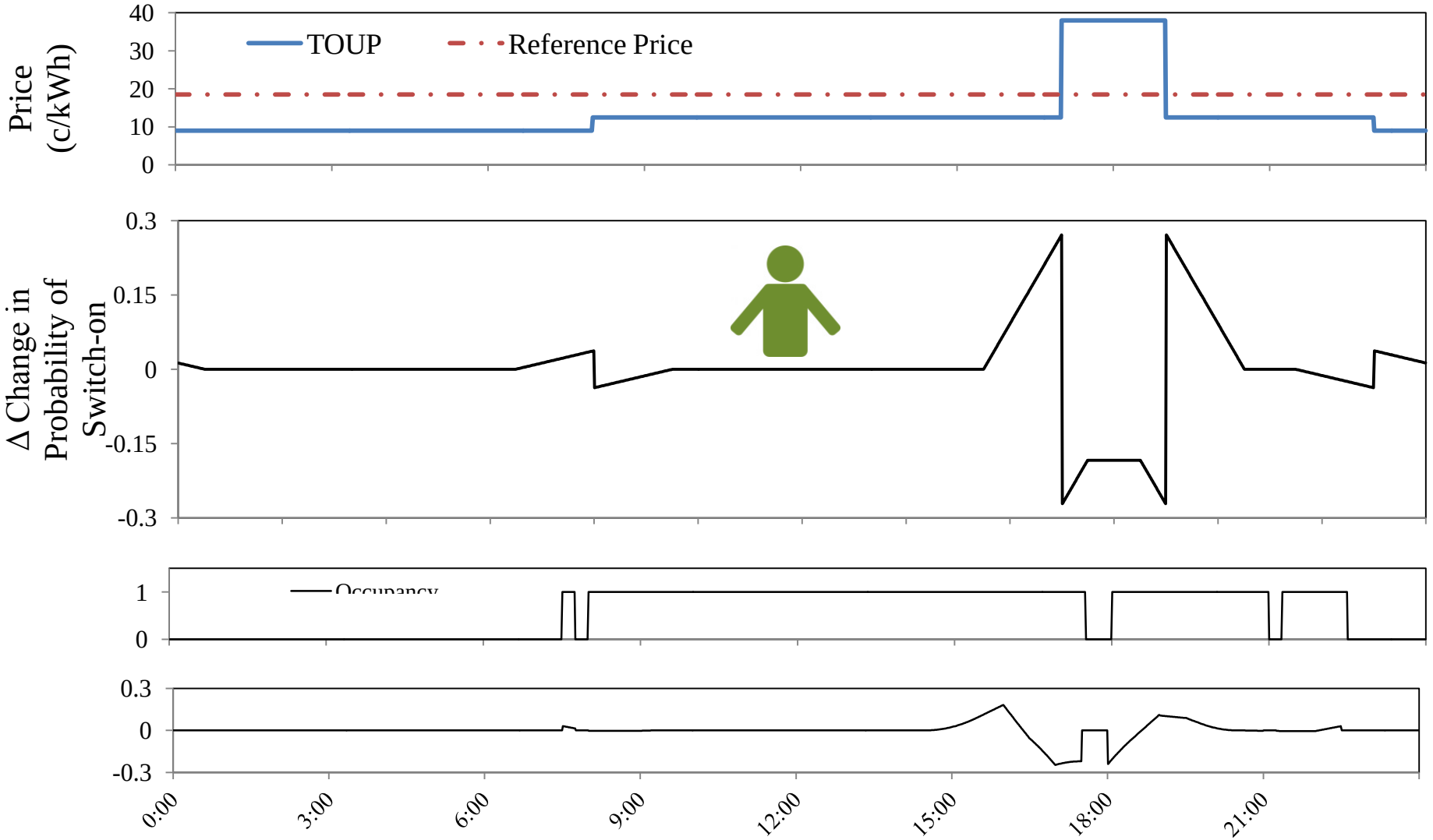
Modelling Price Response

Modelling Price Response

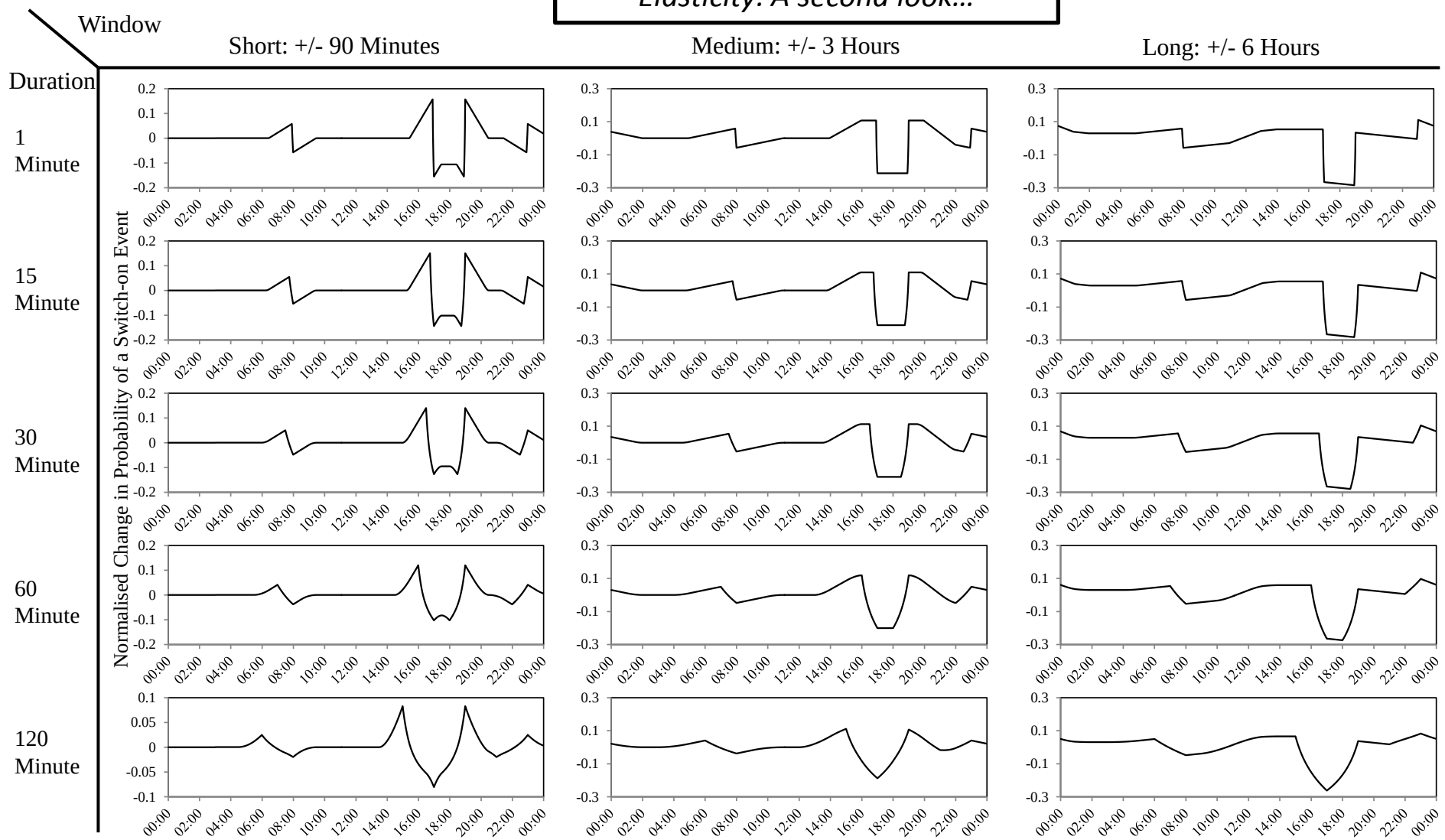
CONSUMER RESPONSE
~PRICE ELASTICITY OF DEMAND~

AUTOMATED DEMAND RESPONSE

Elastic Demand Response



Elasticity: A second look…



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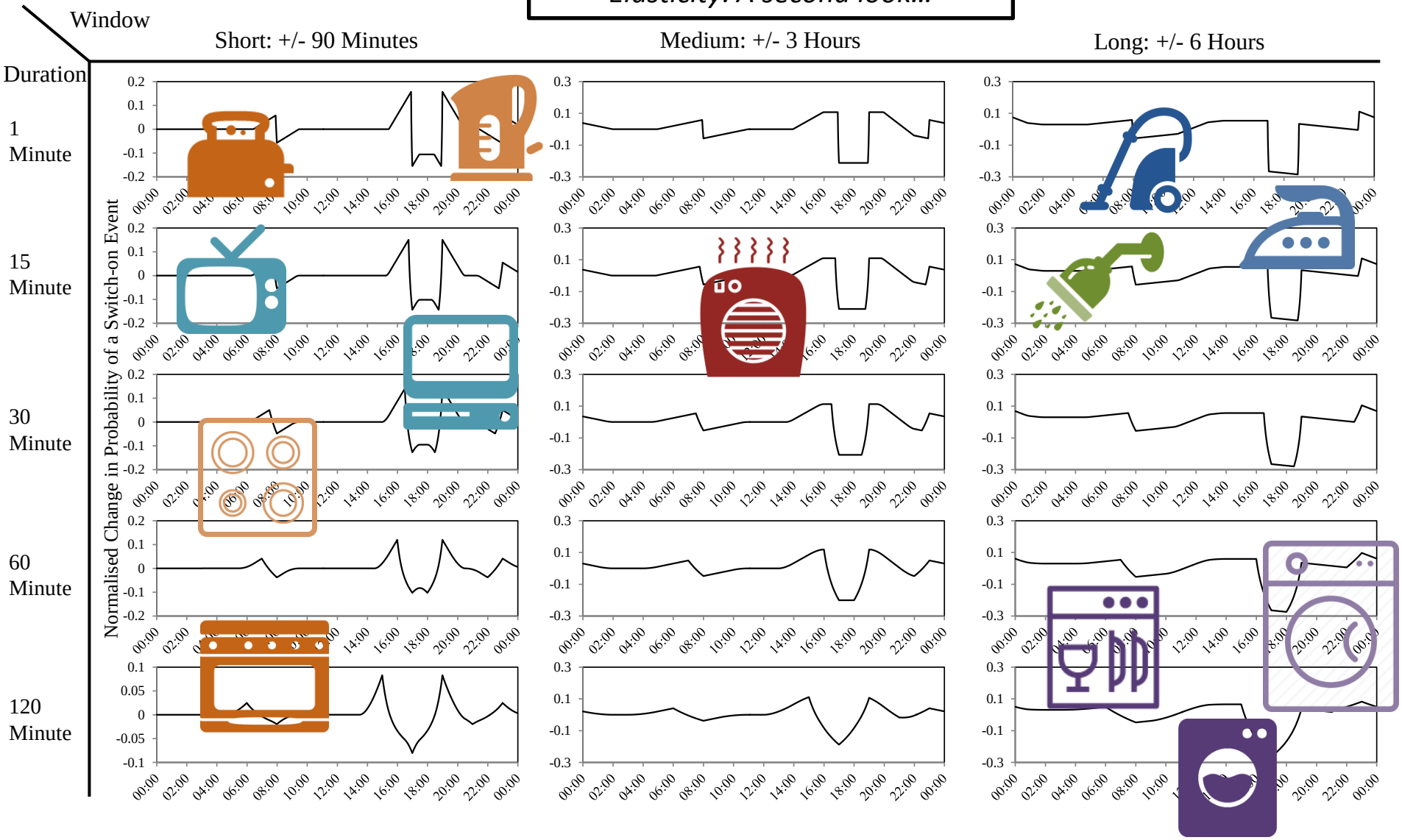
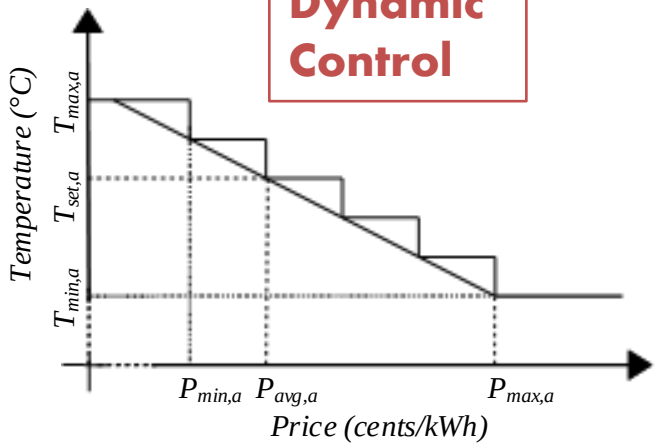
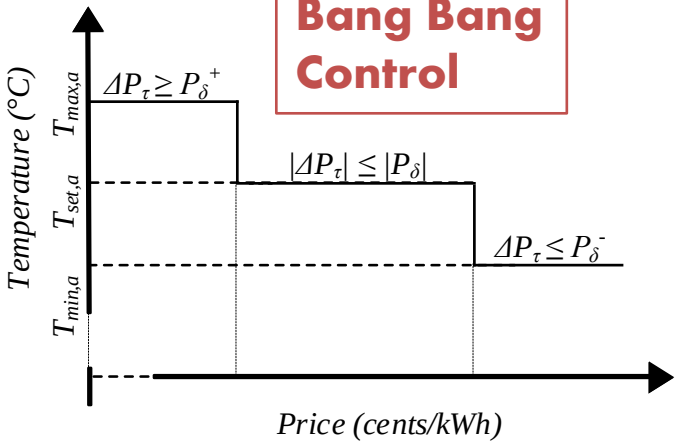


Automatic Demand Response – Thermal Control

Dynamic Control



Bang Bang Control

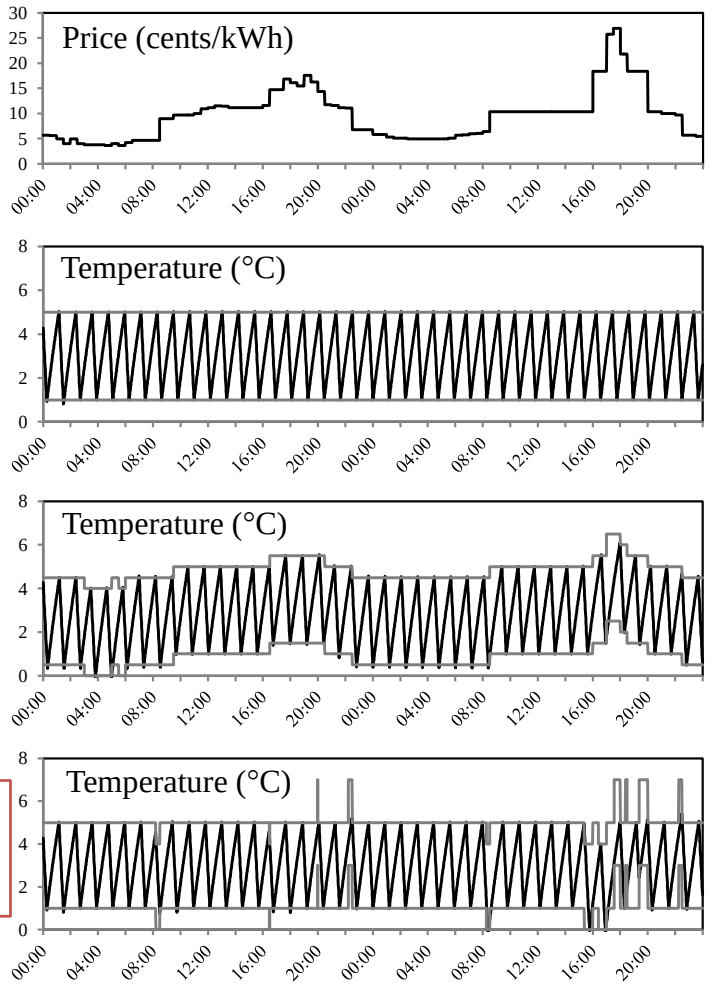


Pre-heating/Pre-cooling & Postponing

No Control

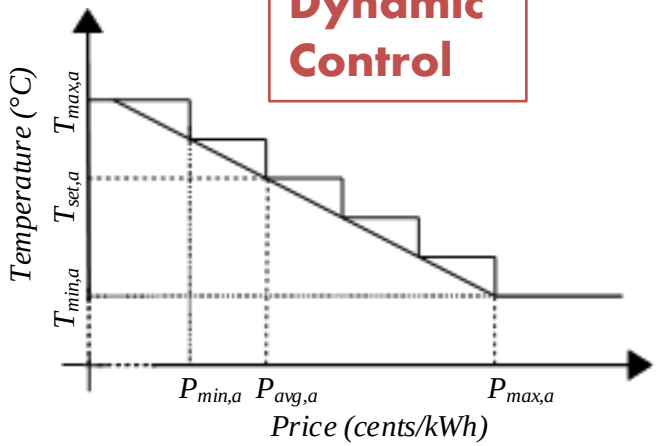
Dynamic Control

Bang Bang Control



Automatic Demand Response – Thermal Control

Dynamic Control



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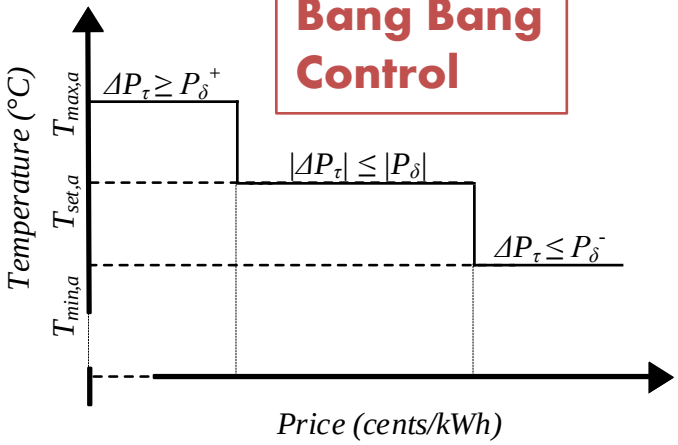

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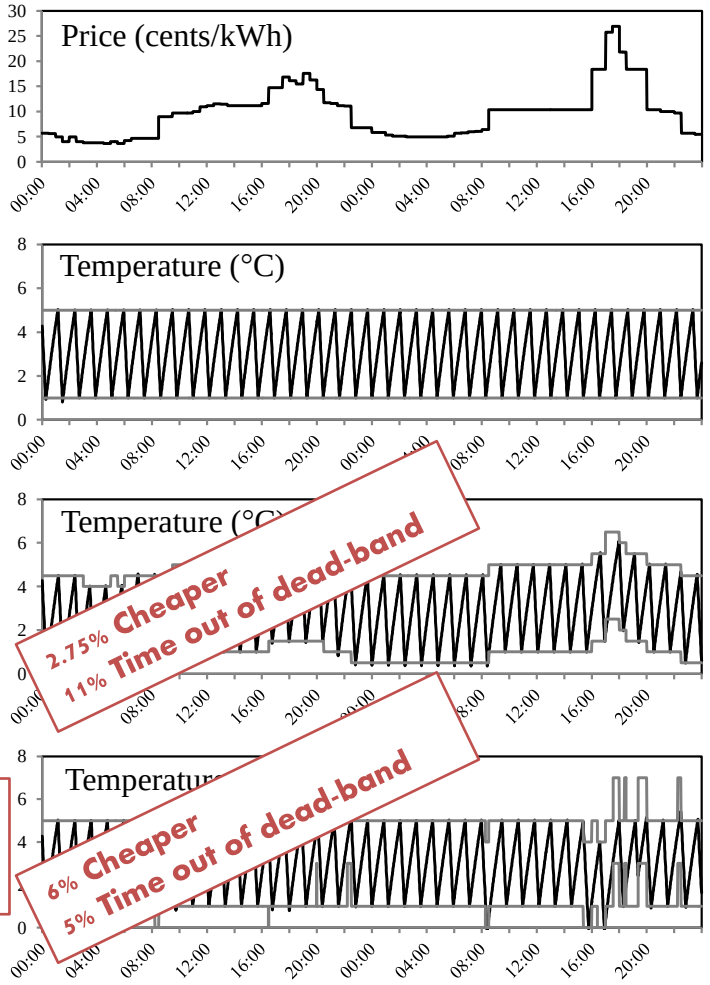
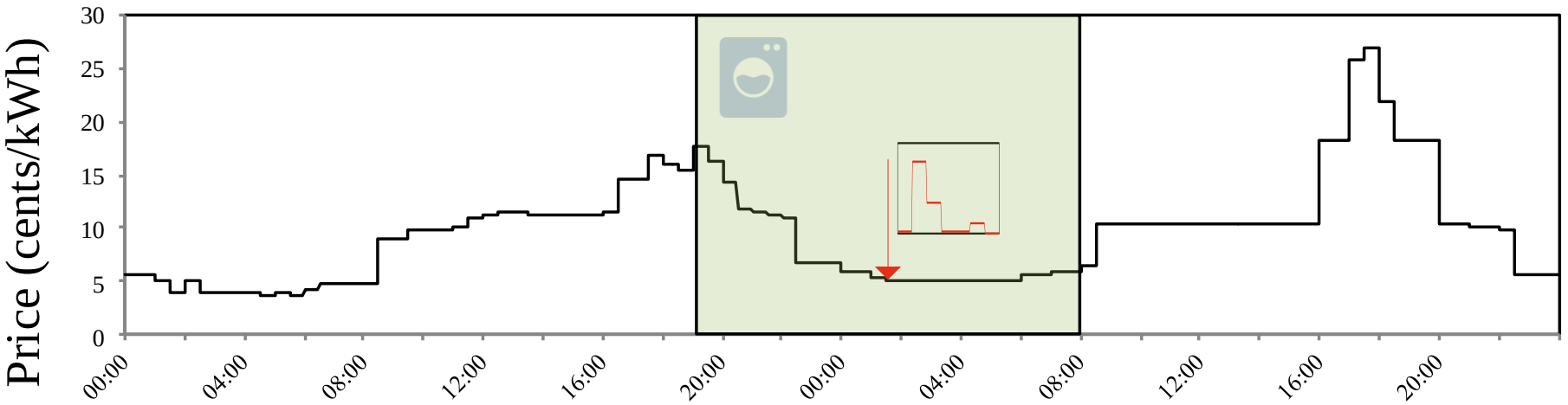


ENERGY INSTITUTE UCD

erc electricity research centre

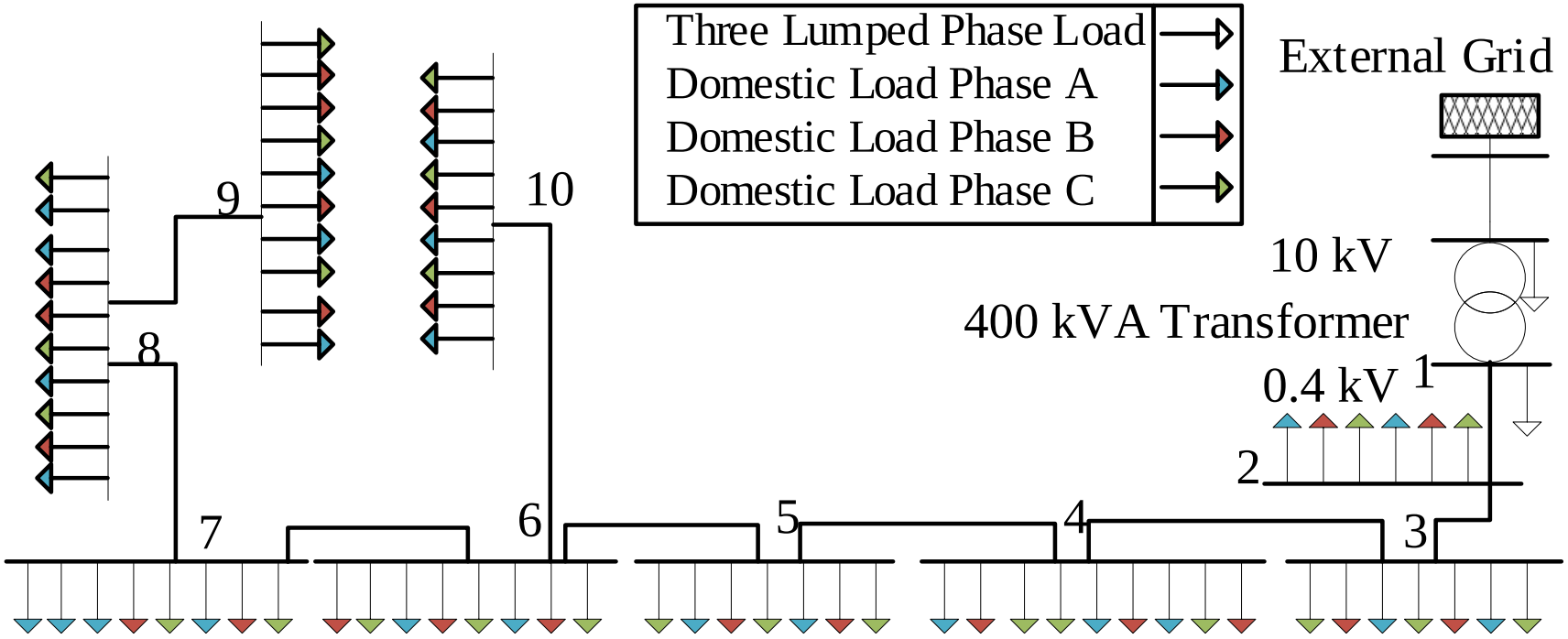
Automatic Demand Response – Optimal Scheduling

- Consumer chooses start-time and end-time
- Controller optimally schedules the appliance to the cheapest start time.



TEST CASE

Low-Voltage Distribution Network



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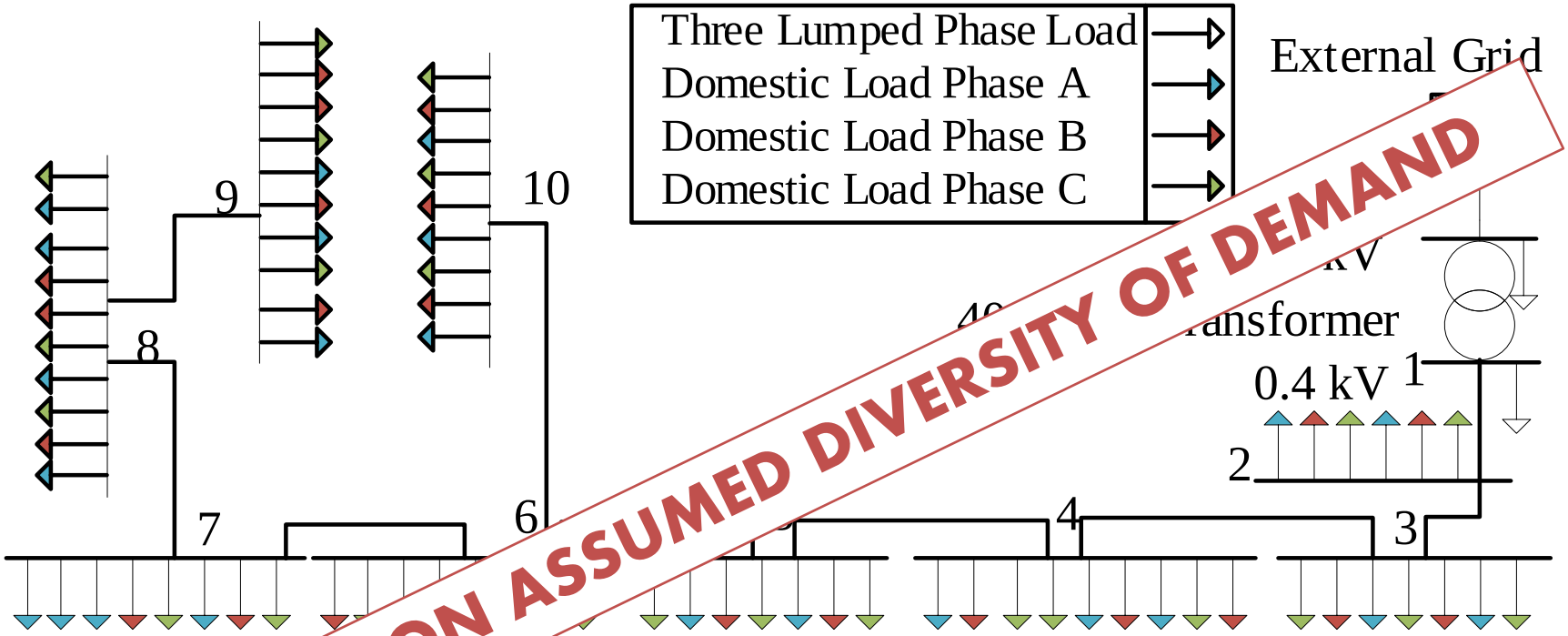
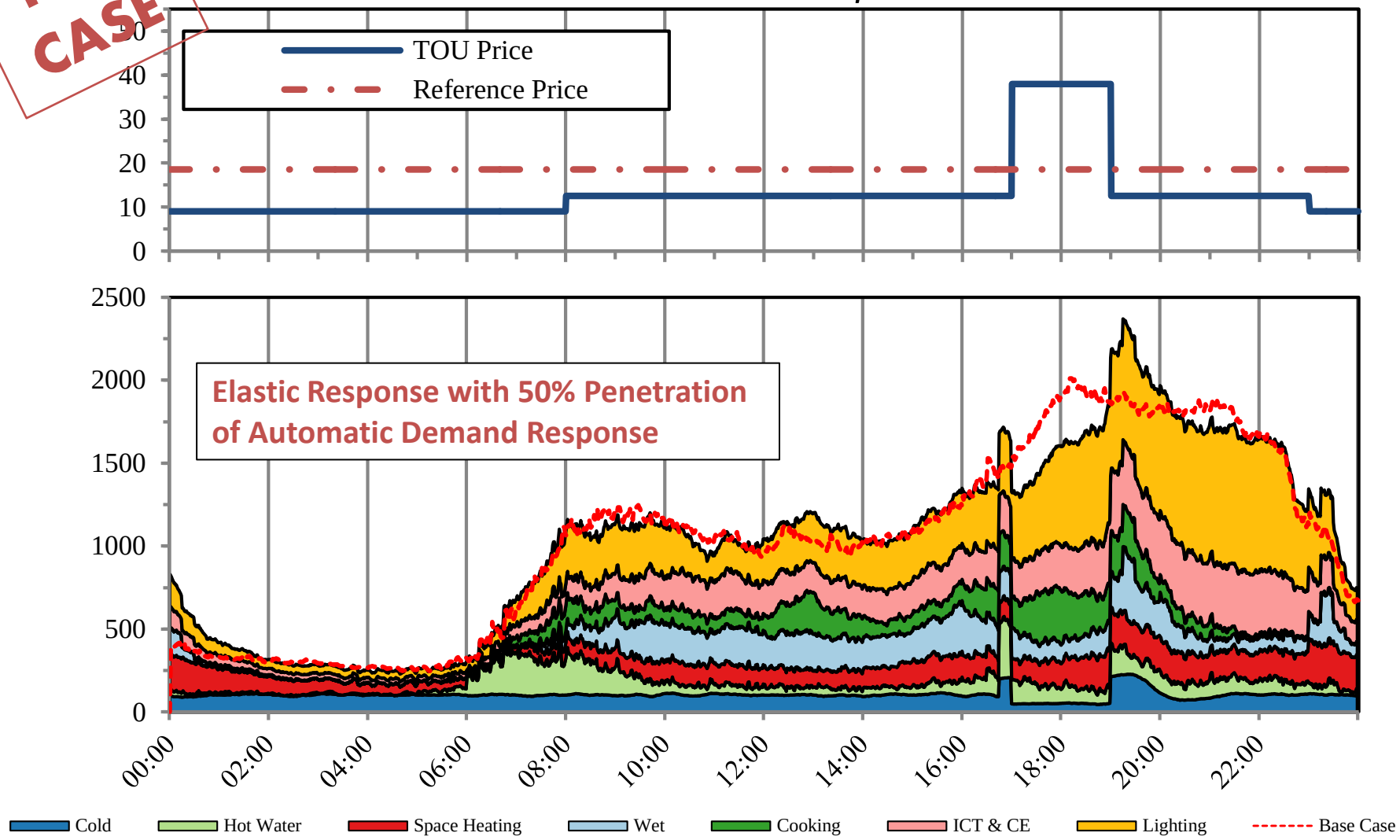


BUILT ON ASSUMED DIVERSITY OF DEMAND

TEST CASE

Case Study: Time of Use Pricing
Elastic & Automatic Response



But what is the objective of dynamic pricing of electricity…?

CO_2 Reduction?

Defer network & capacity investment?

Reduce consumer costs?

Integration of renewables?

Alleviate peak demand?

Increase economic efficiency?

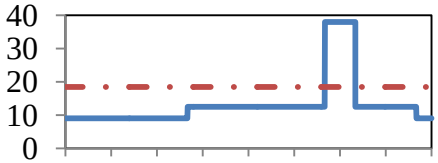
Increase energy efficiency?

SYSTEM-WIDE ANALYSIS

SYSTEM-WIDE ANALYSIS

PRICE SIGNALS

TOUP, DAP, CPP



SYSTEM-WIDE ANALYSIS

PRICE SIGNALS

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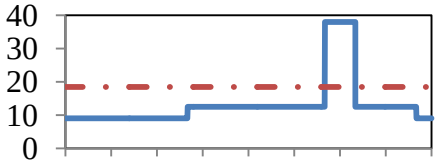
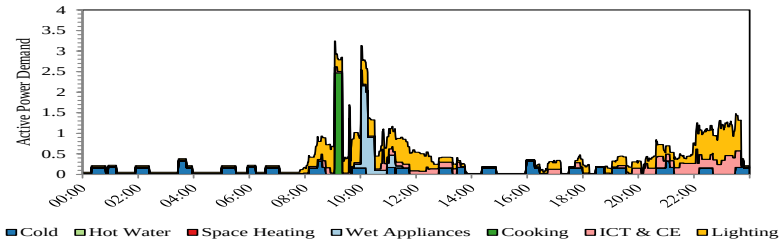


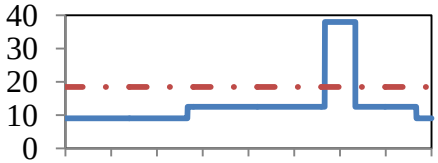
RESIDENTIAL MODEL

ELASTIC RESPONSE AUTOMATIC RESPONSE



SYSTEM-WIDE ANALYSIS

PRICE SIGNALS
TOUP, DAP, CPP



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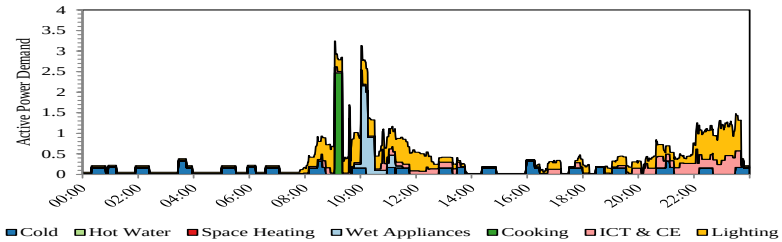
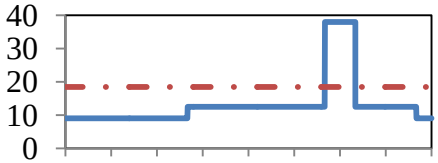


GENERATION-LOAD MODEL
GENERATION DISPATCH, CO_2 EMISSIONS

SYSTEM-WIDE ANALYSIS

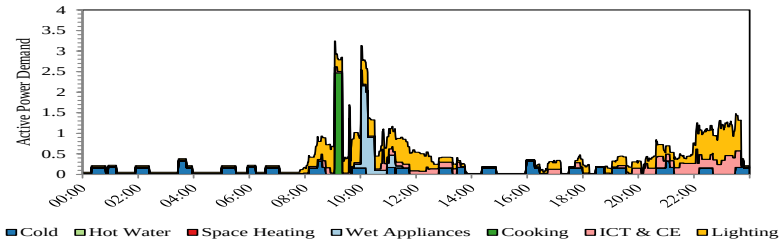
PRICE SIGNALS

TOUP, DAP, CPP



RESIDENTIAL MODEL

ELASTIC RESPONSE AUTOMATIC RESPONSE



GENERATION-LOAD MODEL

GENERATION DISPATCH, CO_2 EMISSIONS

ANALYSIS

PEAK DEMAND, CONSUMER COSTS, SUPPLIER REVENUE, CO_2 EMISSIONS, ENERGY CONSUMPTION, CROSS-SUBSIDISATION

Modelling the Residential Consumer: Electricity Demand & Price Response