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The Role of Smart Meters in the Grid

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Outline

- The grid paradox
  demand is down but the grid expands

- What then with "smart meters"?

- Summary

The Grid

- Connectivity for "electrical **power**"
  - Connects a few large generators to many customers (presently)
  - Supply follows **demand** (within capacity constraint), peak demand is an absolute tyrant
  - Grid must tolerate faults without loss of supply
  - Supplies "**Voltage**" and "**Power**"

    big consumers pay for both; in energy and power-factor prices

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The Grid Paradox

Actual demand is down

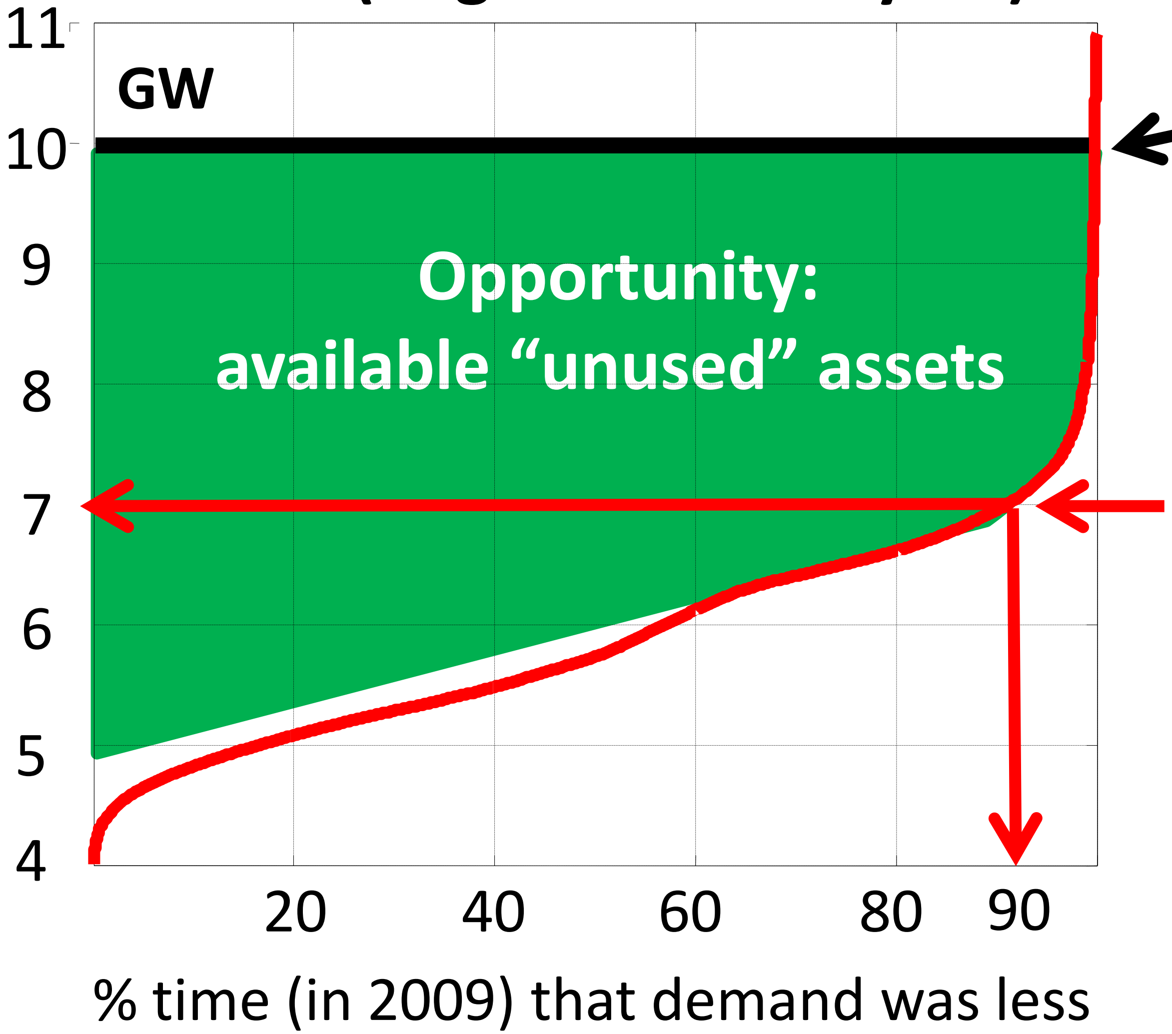
- 5 year downward trend in actual demand in Victoria because of efficiency gains, loss of big industry, embedded generation (e.g. PV), mild summers

but

- Embedded generators “do not (have to) operate under fault conditions” & “do not support Voltage regulation”, do not cope with combined “fault & peak” demand
- Population growth (&GDP growth) determine underlying demand trend, so “grid design demand” goes up and

***the grid expands*.**

Electricity demand curve Victoria 2009 (largest demand year)



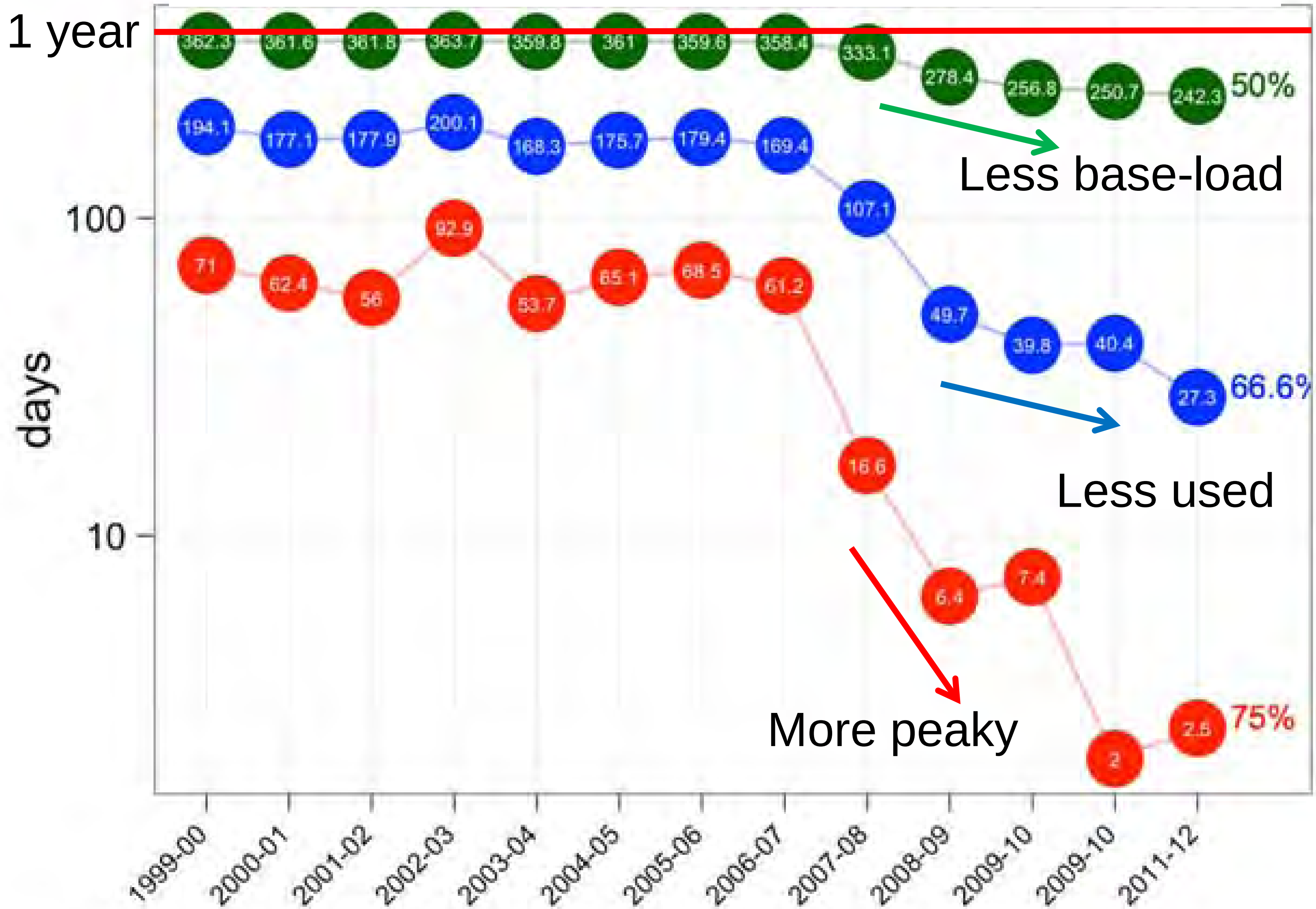
Summer generator limit 10GW

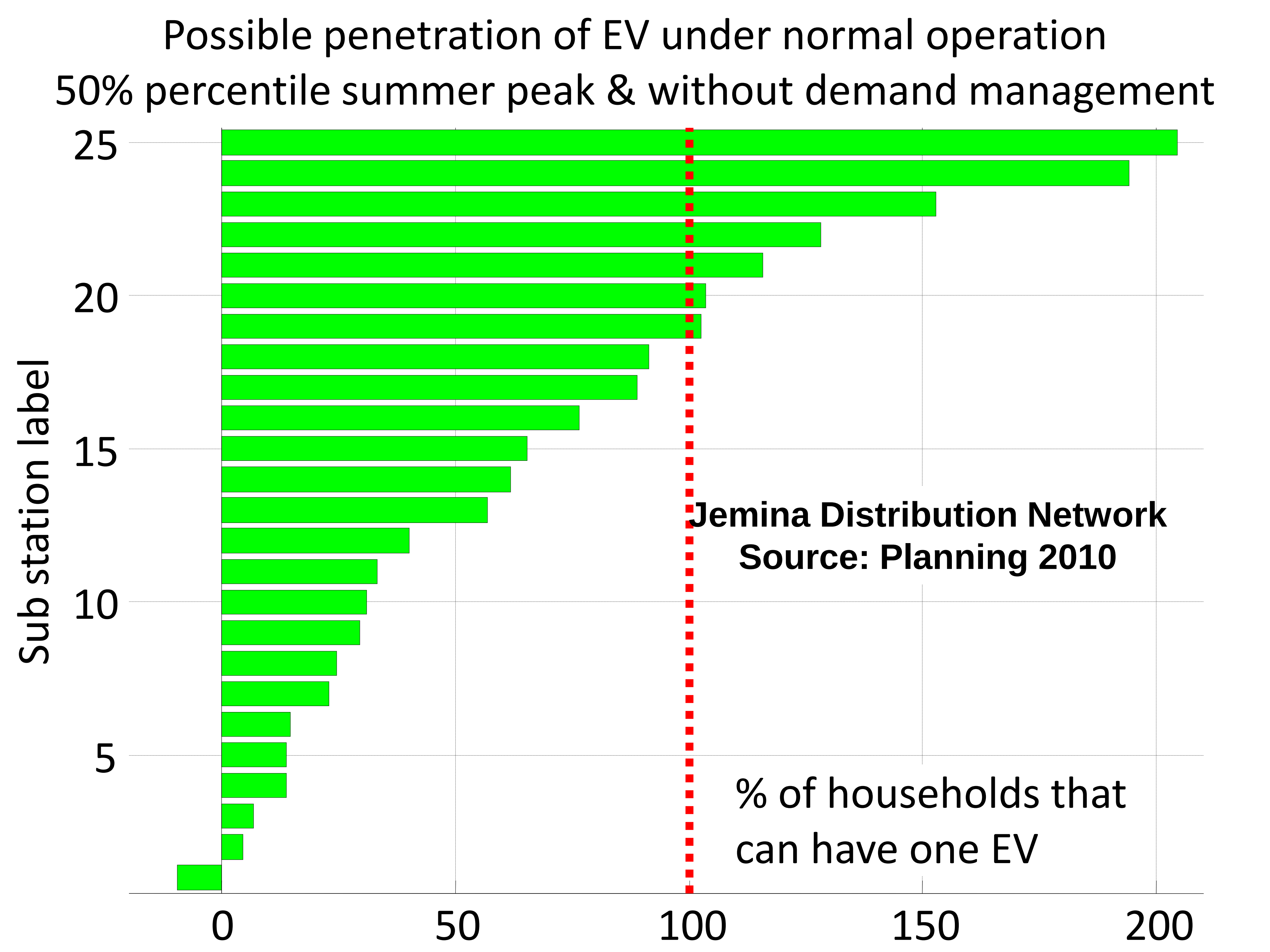
More than 35% of the grid is only used for 10% of the time

Getting worse

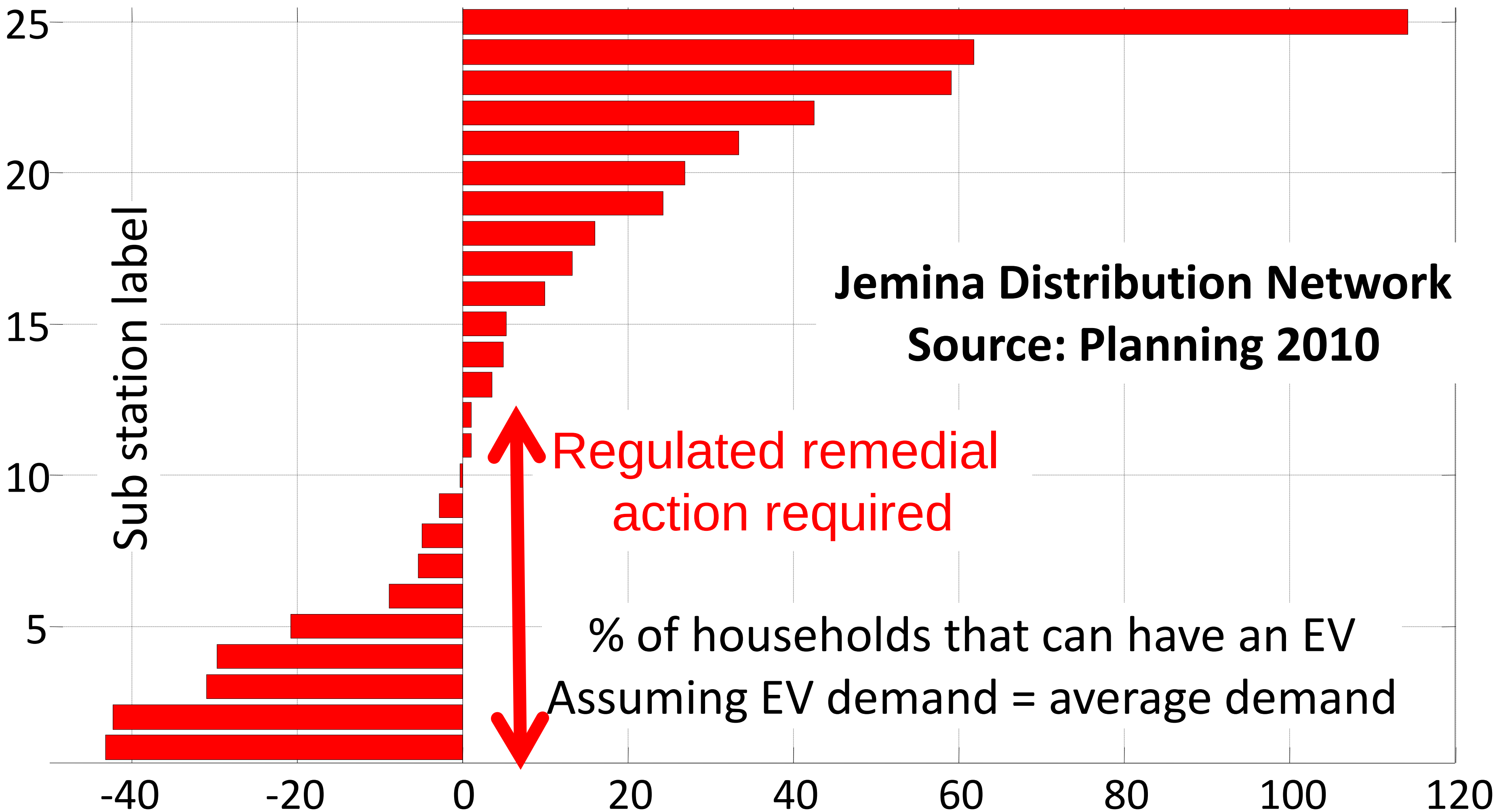
In 2012, 25% of the grid will only be used for 8 hours < 0.1%

The macroscopic grid demand picture




Possible penetration of EV under normal operation
50% percentile summer peak & without demand management
25
20
15
10
5
Sub station label
0
50
100
150
200
Jemina Distribution Network
Source: Planning 2010
% of households that
can have one EV

Possible penetration of EV under "1%" fault operation at 50% percentile summer peak without demand management



What then with smart meters?

- Two key dogmas determine the present "grid picture"
  - **Dogma 1: No electrical storage**
  - **Dogma 2: Consumer demands power "NOW"**

BUT

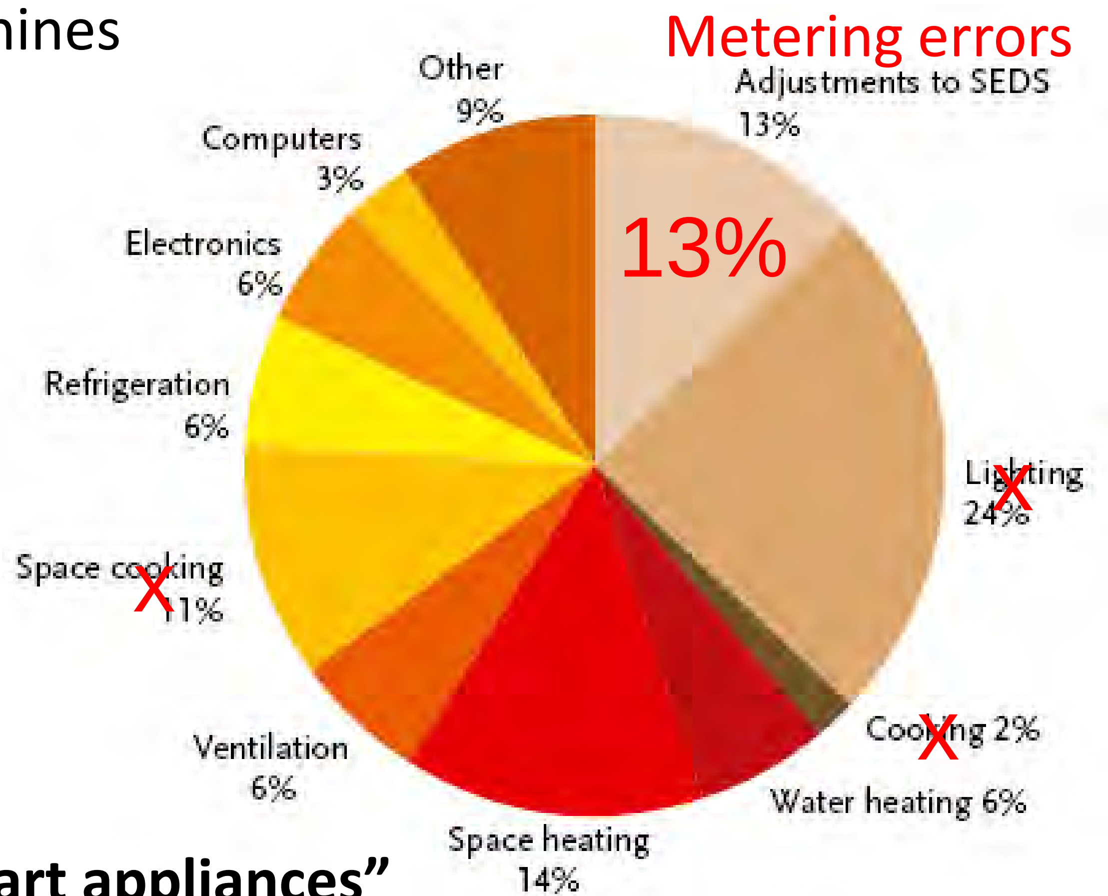
- Energy storage is everywhere (if you care to look)
- Power demand can be controlled / manipulated, within the limits of providing the required service (energy related)

Herein lies the "smart meter" or "smart grid" opportunity

Power vs Energy

Appliances with significant energy storage make up 40% of typical building electricity demand (USA 2003 data, AU 2010)

- Driers, washing machines
- Fridges, freezers
- Air conditioners
- Water heating
- Electronics (battery)



In an EV rich future this may rise to 75%

Need “smart meters” “smart appliances”

Example 1 – Electric vehicles

- **A maximally profitable battery charging policy** informed by the electricity market spot price, and the state of charge in every battery in the fleet, meeting network constraints (other demand)

- **Enabled by a smart meter, smart grid, smart battery**
  - **EV consumer purchases "driving range"**
  - EV supplier buys as an **aggregator** in the market place
  - Vehicle battery state is metered (e.g. SMS, 2 min cycle)
  - Vehicle battery charge power is controlled
  - Low voltage network state/constraints are communicated (meter data identify load profile, and hence spare capacity); hence transmission network will **cope by design**

- **Economic benefit from "unused grid assets" & "information"**

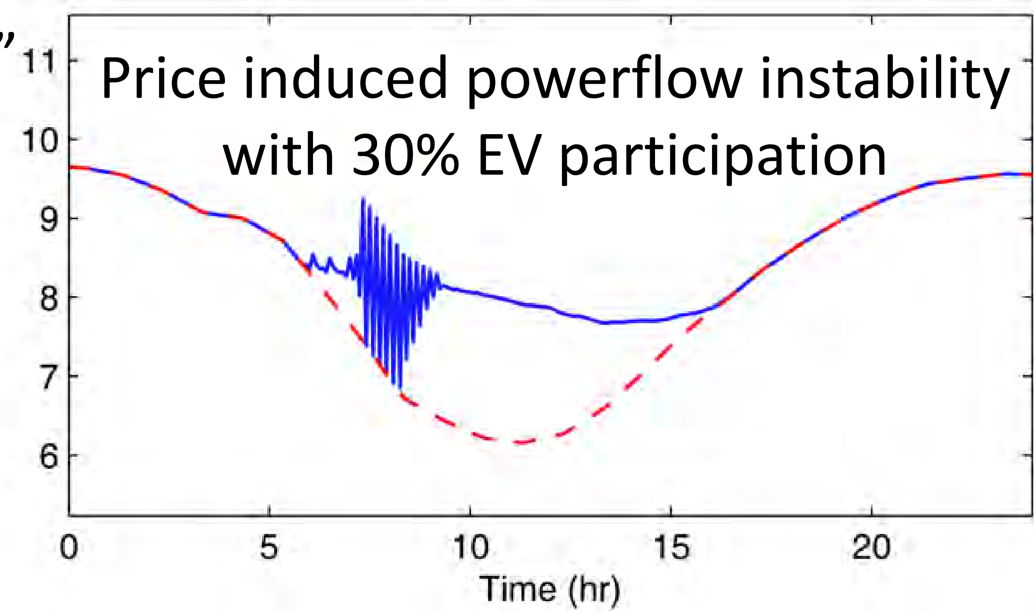
Example 2: Shaping demand …

Exploiting thermal energy storage (need more than price signals!)
30% participation = 15% of total demand "available for randomization" (in the range of 1GW - 3GW in Victoria)

- Typical sensitivity of human < 1 °C
- Thermal mass of home, fridge, freezer, washing machine, dryer, dishwasher is substantial (0.1°C = 20min – 1h time!)

"0.1 °C degree randomization"

- Significant demand smoothing: peak reduction
- Follow renewable supply (wind, PV)



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Summary

- The grid is designed for power connectivity.
  Peak power demand, protection and fault tolerance are the significant design parameters.

- Smart metering **data** allows one to explore the difference between “energy” and “power” in supply. Focus on the “service” not the “power”. **Consumers buy energy, not power**. This can result in evening out demand over time, or demand tracking renewable and unreliable supply sources.

- Regulations, new technologies and markets have to work together to realise “win-win-win” (providers, consumers, environment)

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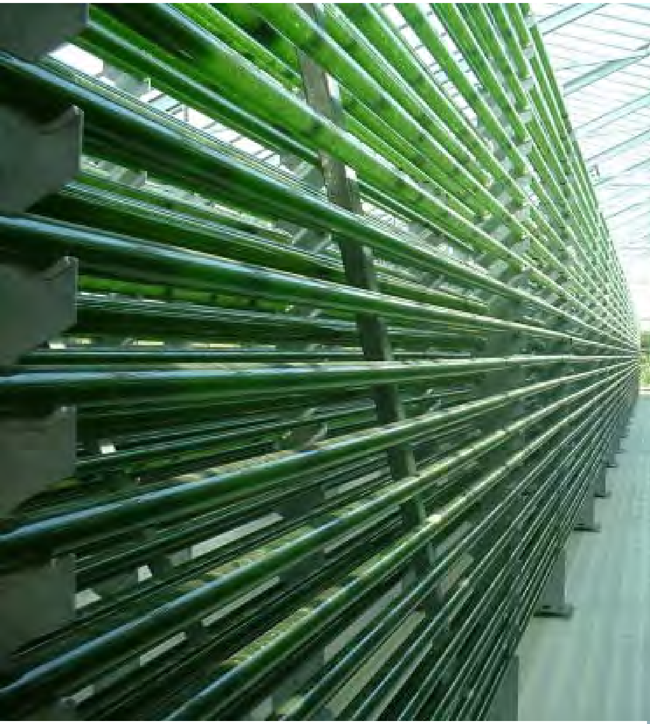
Singapore's present energy need > 27 W per m^2



20W per m^2

80MW Canada
mean < 50% peak

1-3W per m^2 biofuel
average ≈ 90% peak

average < 50% peak
20W per m^2
20.3GW Hydro Station

7MW – 80m blade

25W per m^2

mean ≈ 60% of peak

mean ≈ 40% peak

45W per m^2

mean = 98% of peak

30kW per m^2