A sensible energy policy for Australia

- Energy use in Australia costs $70-80b per year
- Australia uses almost twice as much energy per capita or per $GDP as equivalent economies
- A 40% reduction in Victorian energy use to bring us to current international standards is equivalent to the entire state health budget-20% more than the state education budget
- Australia imports 20Gl of liquid fuels per year. Three submarines could close Australia down in 4 or 5 days

Energy Efficiency Potential

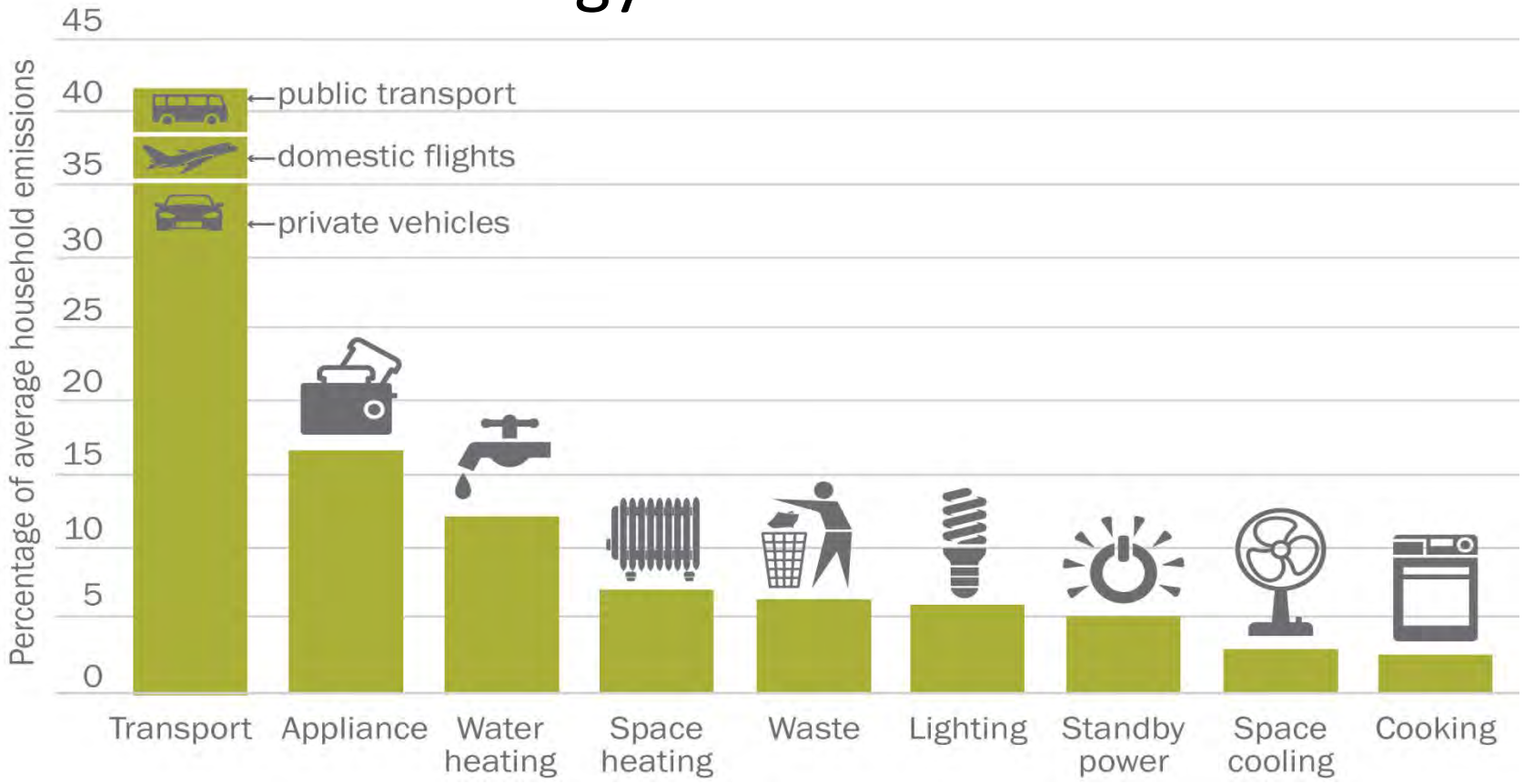
Country	Energy /capita MJ.	$1000 GDP per MJ.	CO2 tonnes per capita	CO2 tonnes per $M
Australia	5.8	17.9	18.6	400
Victoria	6	16.7	19	450
UK	3.1	29.3	8.5	200
Spain	2.7	28.6	6.2	200
Norway	5.9	26.2	9	200
Germany	3.8	26.2	10.2	200
Poland	2.5	21.4	8	400
Sweden	5.1	20.2	4.5	100
New Zealand	4.2	19.1	7.5	200
US	6.8	19.0	18	400
Canada	7.2	14.3	16.8	400
China	2.1	14	4.7	700
Saudi Arabia				

Australia is the third highest energy user per capita

The second least efficient in the OECD even worse than Saudi Arabia

Opportunities for Victoria

- Household energy use



Energy Efficiency

- Average household energy consumption
  - Electricity- 19kW.hr/day = 25 GJ per year
  - Gas-55GJ/yr. (Vic), less in other states
  - Transport fuel - 55-60 GJ
  - Total 120-140GJ (36,000 kW.hr)/year/household
- Best current practice
  - Electricity *6 possibly 7 star housing, High efficiency appliances*
  - Gas *almost all replaced with electricity*
  - Transport fuel- *Fuel efficient cars, Sydney level of public transport, some electrified vehicles*

Target 40% reduction non industrial energy use

Housing Stock

6 star house energy consumption is 150MJ/sqm vs 350 MJ for 1960-90 construction

Building industry innovation means 6 star homes now cost less than conventional

Californian and European standards are approaching 70-80MJ/ sq.m

Energy use per household has been falling 5% per year = 40% over 10

New and rebuild houses replace about 2.5-3% of stock per year = 30% over 10 years

Annual Electricity use in <u>non</u>-solar houses in Qld. has fallen from 7.4MW.hr to 6.3 in 3 yrs.

New appliances typically use half or less energy than 10 yr old models

Energy saving in Households

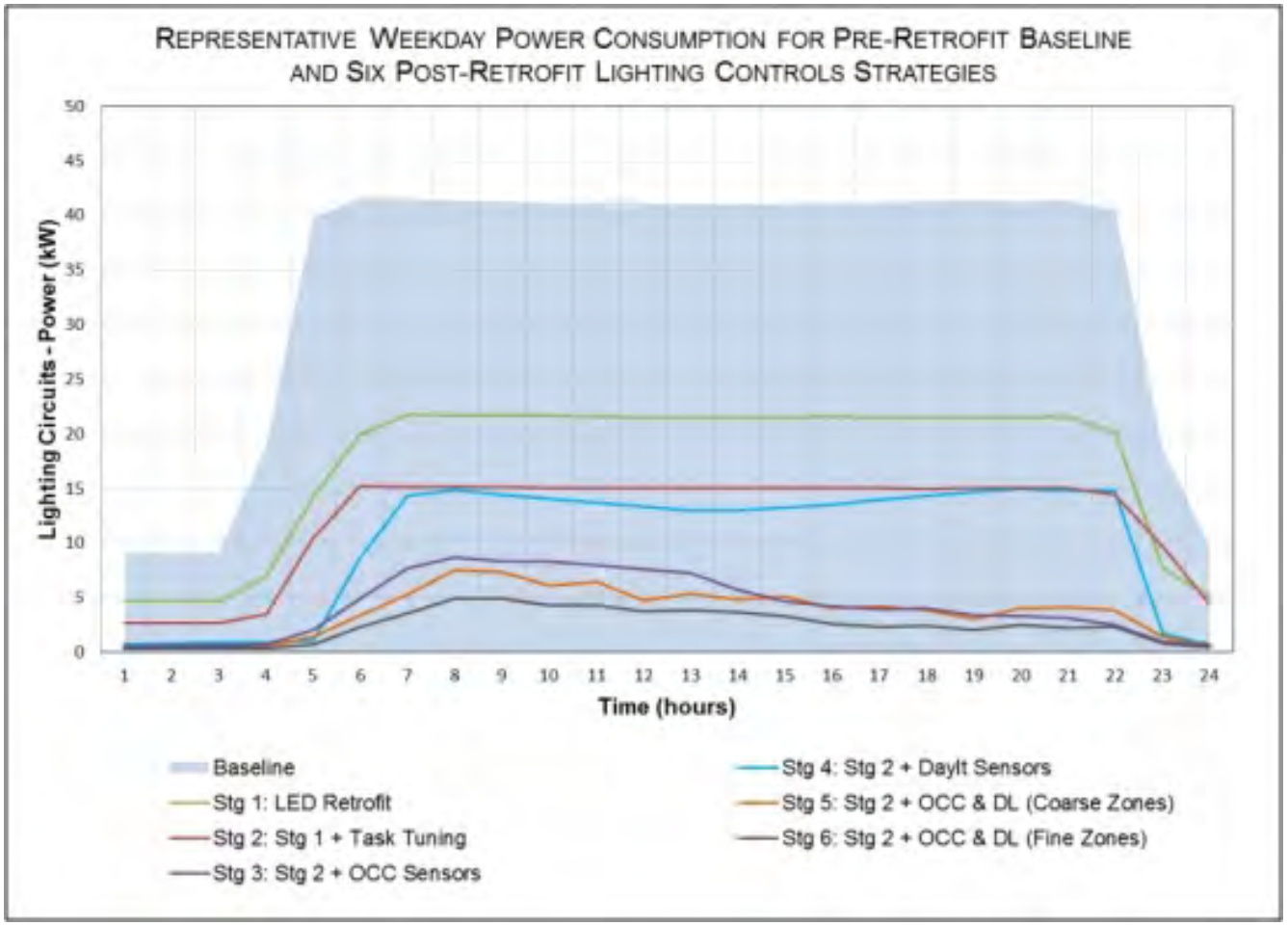
- *Increase 6 star+ homes from 5% to 30+% of stock. Move toward Italian/Californian standards building standards 70-90 MJ-sqm*
- *Increase solar/solar electricity + heat pump hot water from 5-10% to 50%*
- *Replace almost all gas heating with high efficiency heat pumps with storage for heating and cooling*
- *Increase LED lighting, insulation and appliance efficiency in existing stock.*
- *More active auditing of performance vs promise*
- *Improve insulation, window efficiency and sealing and process efficiency in existing stock.*
- *Require energy use reporting at time of sale*

Target 40% reduction

Other buildings & lighting

- *LED street lighting reduces power 40-50%, Smart controls another 20-30%. In some cities street lighting is half the council budget*
- *In 2005 US building energy consumption was projected to reach 54 Quads by 2030. It is now expected to reach 32 Quads including 6b sq.ft of new floor-space saving the equivalent of 150 Coal power stations*
- *New RCH uses 45% less energy than old. Dockland library 50% less than average public buildings. Monash residential building 45% less than comparable older buildings*
- *Modern office retrofits use 30-45% less energy. CDC (France) estimates retrofits of 4-6% of building value produce a 40% reduction in energy and doubling of Building NPV*
- *Modern chillers for food, pharma, hospitals and large HVAC have COP >12*
- *Heat pump, and induction heating can be much more efficient for heating.*
- *Making cold water/ice at night for A/C systems is 20-30% more energy efficient and 40-50% cheaper than running chillers in the heat of the day*

Example of lighting gains



Lighting costs in office building reduced by 80% with current generation LED.
US DoE target is for LED output to grow from 80 to 200 Lumen/watt

Energy efficiency Options

Target 40% reduction non industrial energy use

- ***Transport***

  - *Impose US car fuel efficiency standards. New cars 4.4l/100km vs our current fleet average 12. Current Mazda 3/Corolla around 6 average, fleet Commodore/Falcon 13.50 -60% the fleet is replaced over 10 years*
  - *Encourage electrified vehicles to 20-25% of sales - 10% of registered vehicles*
  - *Increase public transport usage to Sydney levels 17% moving to 24% of commuting journeys*

  Total effect = halving of household transport fuel use

  - *Moving 15% of freight to rail*
  - *Impose US heavy truck fuel standards*
  - *Electrify 20% of short distance parcel delivery*
  - *Electrify main long distance rail lines*

More Low carbon Energy

Why

- Economic stability 9 of past 10 recessions have been preceded by energy price rises
- Energy Security- Reduce oil product imports - currently around 20Gl pa
  - Move towards electrified short distance road and long distance rail transport
    - *Dutch rail system is to be fully powered by renewables by 2016*
  - Use CNG for long distance road transport

Why Low carbon energy

- Reduce city pollution by through more electrification of transport & heating
- Improve land and water usage - less land alienated for renewables than coal/gas
- Reduce water usage
  - *Latrobe valley power currently uses 1.3 Ml/MW.hr approximately 110 Gl/yr. = 30% of Melbourne supply*
- Improve system diversity & reliability. *No 500MW generators to go down in one hit*
- Reduce CO2 output *(Hazelwood 1.6t/MW.hr new US EPA std. 0.5T/MW.hr)*

More reason for renewables

- Reduce heavy metal, PCBs, Furans, NOx, HCl pollution
  - *Latrobe valley power workers are said to die 15 years younger than national average*
- Replace aging infrastructure *Hazelwood, the least efficient large power station in the OECD was scheduled to be closed 12-15 years ago by the SEC*
- Significantly Lower long run costs
- If generation is decentralised, reduce transmission costs

Renewable Energy Possibility

- **How much do we need**
  - Peak demand Vic-10GW +Tas +SA = 14GW
  - Annual Demand Vic-40TW.hrs +Tas +SA = 62 TW.hrs
- *Peak & total demand is falling about 1.2-1.8% per year before retiring Aluminium smelters, car plants etc.* *(Pt. Henry is 7% of total Victorian demand)*
- On current trends without expanded energy efficiency targets 2025 –
  - Peak 11.5 GW,
  - Total 50-55 TW.hrs.

Electrified economy

Sources of additional electrical loads

- Heat pump/solar heating/hot water/cooling for 1 m dwellings 3.6 TW.hrs
- 250,000 electric light vehicles 0.7 TW.hrs
- 50% more tram passengers .004 TW.hrs
- 80% more train passengers .01 TW.hrs
- 1,000 Electric buses 0.13 TW.hrs

Total extra substitution demand 5-6TW.hrs

Achievable generation mix 2025

Electricity sources of the future - 55+ TW.hrs.

Installed capacity	2014		2025	
	Capacity GW	Output TW.hr	Capacity GW	Output TW.hr
Steaming Coal	7.5	47	3	<2
Gas	4	5	2	<1
DICE*			3	7
Hydro	4.5	10	5	10
Wind	2	5	8	26
Solar	2	2.5	10	18
Biomass	.1	.5	.2	1
Wave/Geo-thermal/other	0	0	.5	.5
Total	**22**	**69**	**40**	**62+**

Projected demand at current rates of decline is around 55 TW.hr but electric vehicles, replacement of gas heating, cooking & hot water may slow or slightly reverse demand fall

** DICE uses a refined brown coal slurry in a diesel engine for about twice the energy per kg of coal as current steam generators. It is also modular and much more responsive to changes in demand*

Renewable Energy Reliability

- How reliable is it (night, clouds, no wind etc.)
  - Capacity factor is lower 25-40% vs 80-95%
  - Reliability is higher 98-99% vs 95-97%
    - *Victoria lost over 300MW of coal generation in seconds during January peak*
  - All systems require back up (spinning reserves, hydro).
    - *Texas costing indicates Coal backup is much more expensive than wind backup. Coal needs long ramp up therefore hot spinning reserves*
  - Current NEM thermal system averages 50% capacity
  - Latest German experience suggests an all renewable system needs storage = 10% of peak demand day, significantly less than the spinning reserves in a normal thermal system. VSAT already has that in hydro*

Peak Demand Electricity Sources

Hot dry still day – 11.5-12.5 GW peak demand Vic/Tas/SA

Generation Type	Installed capacity GW	Utilisation %	Output GW
Solar	10	50%	5
Wind	8	5%	0.4
Hydro	5	60%	3
Storage	2	80%	1.6
Dice	3	80%	2.4
Biomass/other	1.5	70%	1
Gas	4	30%	*1.2*
Load shedding/shifting/cogen	(-12)	7%	*.8*
Total			***13.4(15.4)***

Cost of Backup options

	Ramp rate %/min	Capital Cost/MW.hr	Efficiency (part load)	Operating cost/ MWhr
Warm coal generators	2-5	2,000	0-20	$45++
Cold Coal generators	.1-1	2,000	10-25	25-50
Hydro	20-50	2-4,000	85	5
Pumped Hydro*	20-50	3-5,000	60	15-25
Combined Cycle gas	1-5	3,000	30-45	50++
Open cycle gas	3-10	1,500	25	70+
Diesel	10-20	1,800	40+	90
Direct Injection coal	10-20	1,900	40+	30
Grid Batteries*	100-500	300,000+	90	30
Premises Batteries*	100-500	400,000	85	30
Premises Thermal*	100-500	50,000	80-500	20

*These options can have negative operating costs by drawing power at very low prices and re-injecting it at higher prices

Sustainable Energy

How hard is it

- In 2008 the Average solar panel generated 160-190W for about $800. In 2017 most solar panels will be 300 to 350W for about $200. *(300W already available)*
- In 2011 the average wind turbine in Germany generated 2.2GWhr. Recently installed turbines in Australia generate 8-10 GWhr/yr. In 3-4 years time latest generation turbines already in production will probably reach 12-15GW.hr per turbine
- Output of new solar panels in Australia about double the average of installed base in Germany. Same with wind turbines. 2015 Australian cost per MW.hr about one fifth of German 2010 costs.
- For Victoria, SA, Tas, need about 6-7 GW of new Wind and 7-8 GW solar (*Install rate 0.6GW Wind, 1.5 McArthur farms 1 Tas*

Sustainable Energy

How hard is it

- Italy installed 15GW of solar in 3 years, 9 GW in one. UK 1.1GW in the Jan-Mar. Japan 10 GW last year. China 13GW this year
  - *Italy's economy is only 50% larger than Australia, 5 x VSAT - India's economy 25% larger than Australia*
- Bangladesh installs 30-40,000 home solar systems a month say .3-.5 GW.hr per year
- 2013 Germany installed 2.7 GW wind, Canada 1.6, India 1.7, Poland .9, Sweden .7, Romania .7, China 16GW
- Turkey has 50% more wind power per $GDP c/f Australia, New Zealand 220%, Greece 410%, India 519%, Portugal 1,270% more
- Portugal has worked on 70% renewables for the last quarter **plus** exported another 6%. South Australia 30%+, Germany 31% *(Germany also exports much more power to France and other countries than it imports)*

How Much Space 100% renewables

- 7.5 GW new solar = about 65-80sq km
  - A bit over half the Latrobe Valley Power precinct
  - about a third of the area of Lake Corangamite or
  - <10% of the current area of roofs in VSAT
  - *100% solar for all of Australia requires 80-90% roof area of Victoria*
- 7 GW wind is about 950 sq. km of which

only 6 sq. km cannot be used for farming (*total farming area in Victoria/SA/Tas 8,000sq km - Loss of output <$0.5m/$14b)*

  - King Island potential .8 GW++ in 1100 sq.km. possibly 10% of Victoria's power in 2025

More Interesting renewable facts

- Germany has 23,000 turbines in 375,000 Sq km. This year it will install another 1000 and replace 1-200 old machines with much bigger ones VSAT needs about 5,400 in about 1,275,000 sq.km.
- In the Jan half Germany generated 31 Twhrs of renewables 90% of East coast Australian demand. In 2017/18 China, Germany, Japan, the US and possibly India will each generate enough renewable electricity to power Australia
- Japan and china are each installing more solar over the next 3 years than Australia's total generating capacity from all sources
- South Australia is approaching 50% renewable electricity
- Roam consulting has identified about 10-15GW of potential pumped storage capacity in Vic/Tas/SA with >280 GW.hr capacity i.e. about 40 hours of no wind, no sun, no co-gen, empty hydro dams

Notes on Electrical Load Factors

- German solar output is 70% of installed capacity on sunny days which is where our peak demand occurs. Ours will be lower because of longitudinal spread from Eastern Victoria to Port Lincoln. Possibly a little higher due to higher radiation levels

- Worst case current wind output on NEM is about 5% of peak but new turbine designs are optimised for low wind speeds so worst case should be higher. *GE is offering wind turbines with inbuilt batteries to spread supply*

- Storage can be pumped hydro, batteries (static or flow), flywheels, ice, hot water, electric vehicles (C2G)

  - *It would be quite easy to achieve*

    - *40+GW.hrs of ice storage for cooling in summer - 20% of houses with 250l, supermarkets, hospitals etc. 600-20,000l*

    - *25-30 GW.hrs of hot water in winter.*

      - ***This is 15-20% of high day demand***

  - *Large Batteries are dropping from $1.5-2,000/kW.hr. for 200-500 cycles towards $3-500 kW.hr. and 5,000 cycles in 2017. Chevy Volt batteries available now for $150/kW.hr*

Notes on Electrical Load Factors (cont.)

- Load shedding/shifting:
  - *Modern air conditioners, dishwashers, pool-pumps etc. are fitted with circuits so they can be turned off by the network for 30-40 minutes at a time sharing the load in a district.*
  - *Cool rooms etc. can be supercooled at night at much lower cost. Night COP 7-10 warm day COP 2.5-4*
  - *Some large customers agree to reduce load on high demand days for a fee or lower off peak prices. Norway has 2GW demand response market in a market of 24 GW peak*
  - *Austin Energy (Tx) has introduced "Rush hour Rewards" paying households $85 and subsidising internet connected house thermostats. This means Austin Energy is not paying generators up to $5/kW.hr for energy they are supplying to the customer for 12c. In the first year 5,500 households reduced peak demand by 5.7 megawatts for 3-4 hours a day and AE are expecting 13MW this year 1st year savings if working for 50 hours per year ROI for AE is 300% per year*