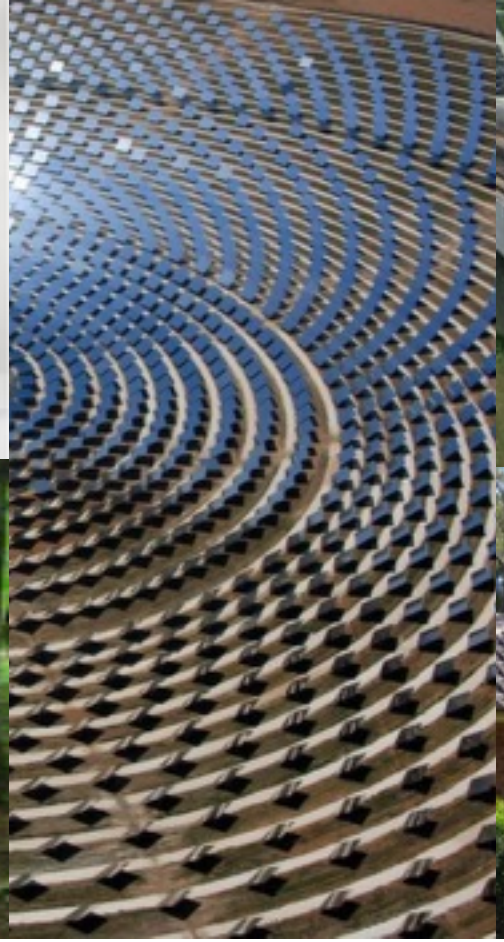




Presentation to Sustainable Engineering Society Victoria

9 November 2015

Stephen Bygrave

CEO, Beyond Zero Emissions

Why beyond zero emissions?

"To limit warming to two degrees, carbon dioxide emissions from the energy sector need to fall to zero by between 2040 and 2070, falling "below zero" thereafter"

"The world can still combat climate change but only if nations raise their collective ambition to achieve a carbon-neutral world in the second half of the century"
Christiana Figueres, UNFCCC

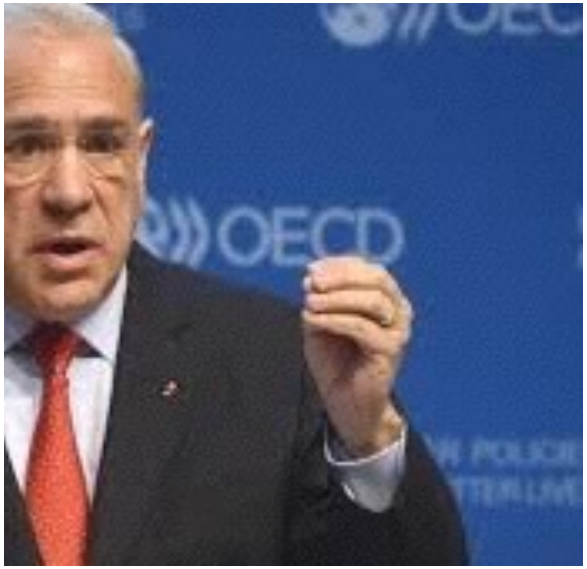
Why beyond zero emissions?

"Global emissions must peak in the next decade, fall by half by 2050, and then decline to zero to remain within that budget"

Achim Steiner, UNEP

"I am making a strong call for governments to put us on a pathway to achieve zero net emissions from the combustion of fossil fuels in the second half of this century"

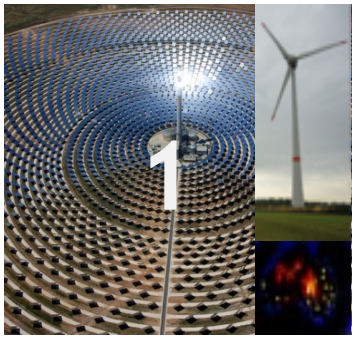
Angel Gurrio, OECD



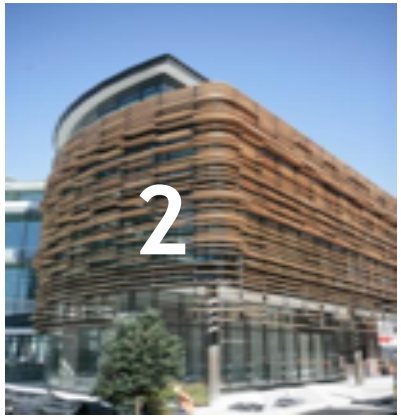
The ZCA Project

Australian National University

The ZCA Project



1. Energy → 2. Buildings → 3. Transport → 4. Land Use → 5. Industrial processes → 6. Renewable energy superpower




Australian Sustainable Energy
Zero Carbon Australia
Stationary Energy Plan


Zero Carbon Australia
BUILDINGS PLAN

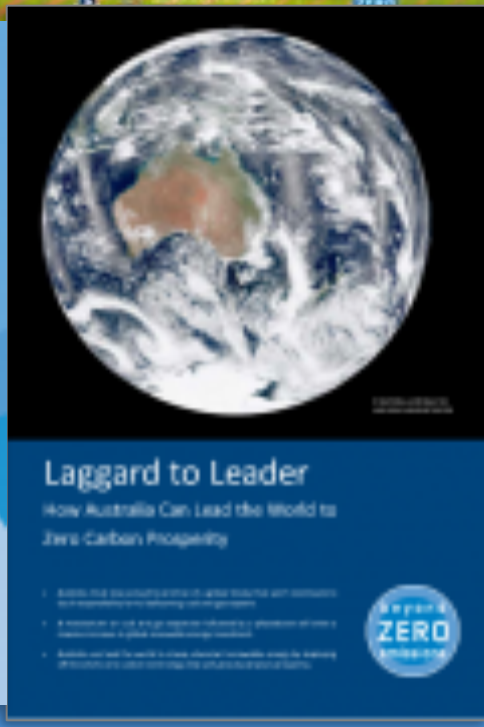

Zero Carbon Australia
High Speed Rail


LAND USE:
AGRICULTURE
AND FORESTRY


Fossil economy


THE
ENERGY-FREEDOM
HOME
Lighting
Draught Proofing
Insulation
Windows
Appliances & Cooking
Heating & Cooling
Hot Water
Energy Monitoring & Control
Solar Power
HOW TO WIPE OUT ELECTRICITY
AND GAS BILLS IN NINE STEPS
BEYOND ZERO EMISSIONS

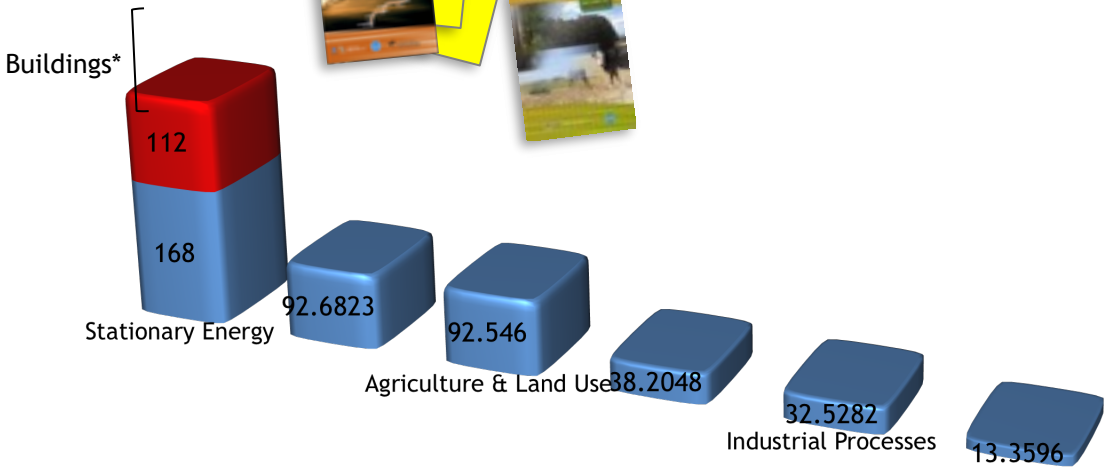

Carbon crisis


Laggard to Leader

Australian GHG footprint

549 Mt CO_2-e

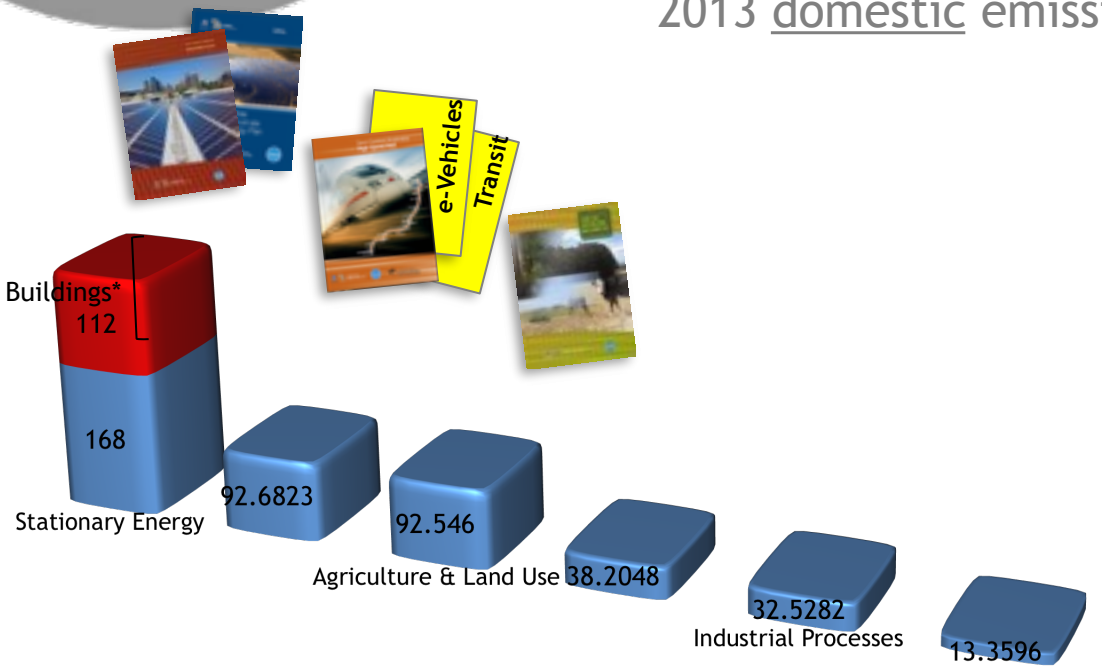
2013 domestic emissions

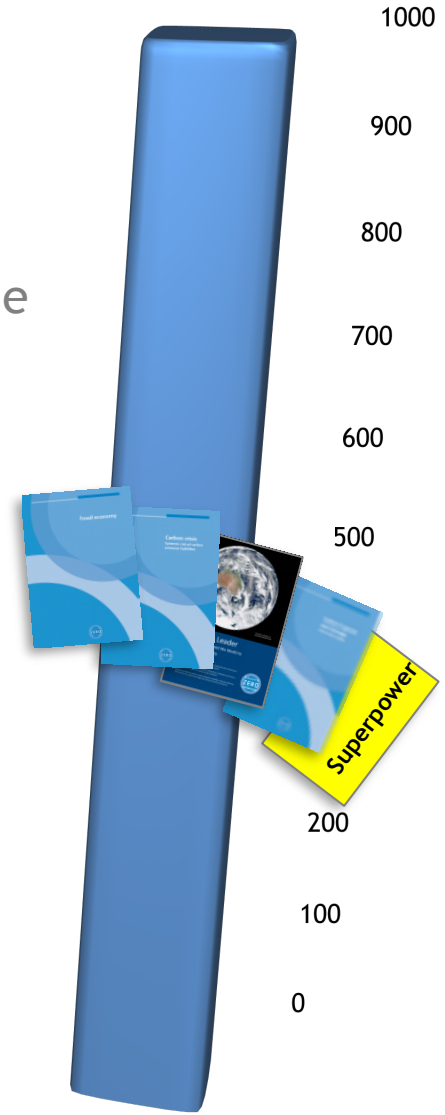


Australian GHG footprint

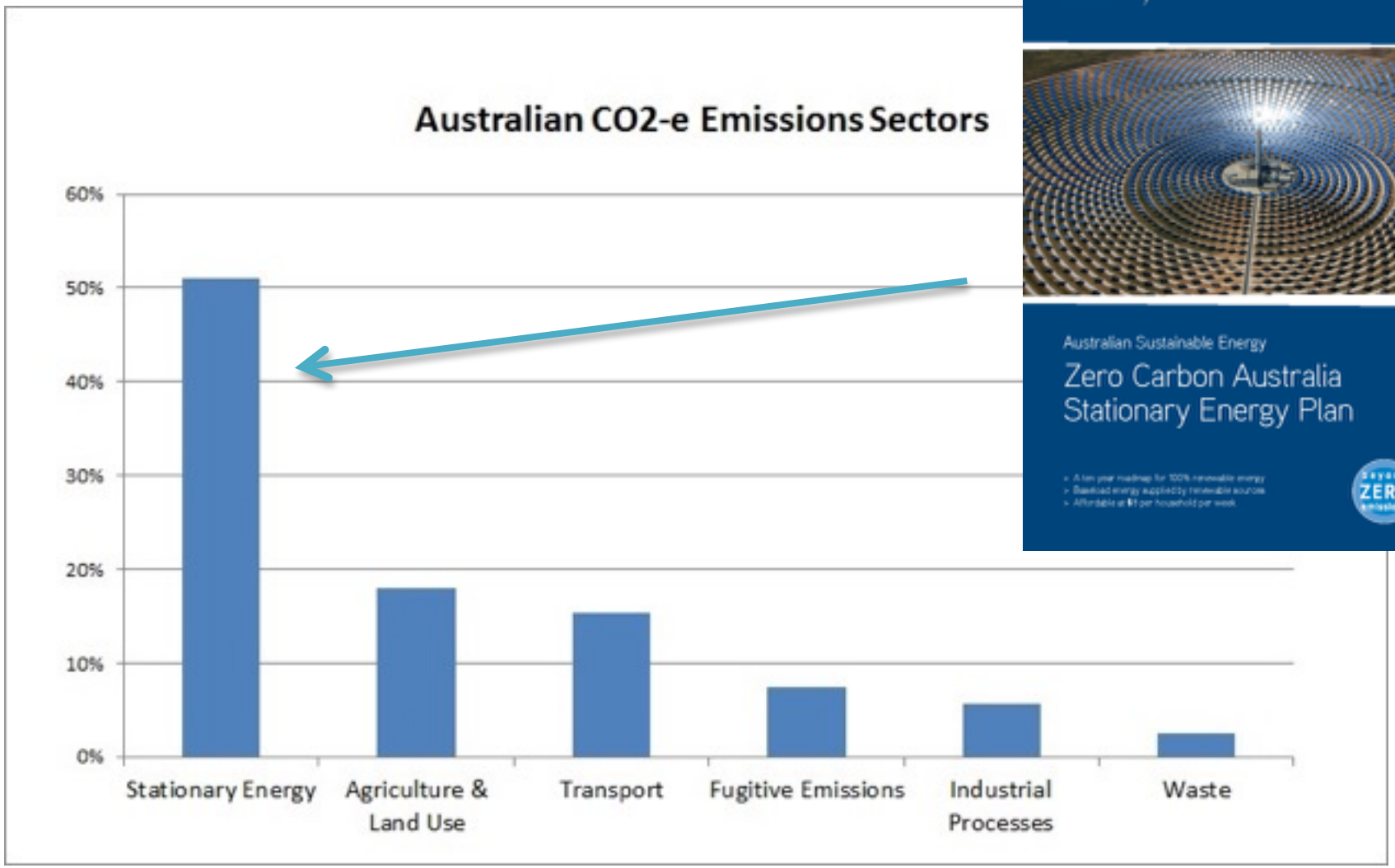
549 Mt CO_2-e

2013 domestic emissions





Energy

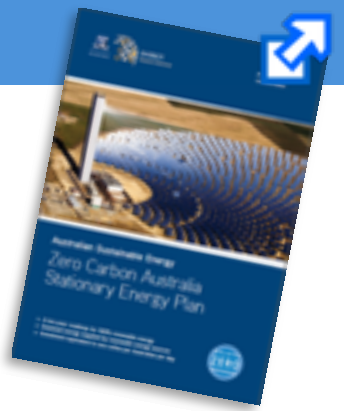

Australian CO2-e Emissions Sectors
60%
50%
40%
30%
20%
10%
0%
Stationary Energy
Agriculture & Land Use
Transport
Fugitive Emissions
Industrial Processes
Waste

Australian Sustainable Energy
Zero Carbon Australia
Stationary Energy Plan

Concentrated Solar Thermal

36 days straight of 24/7 Power

Energy



Published in 2010

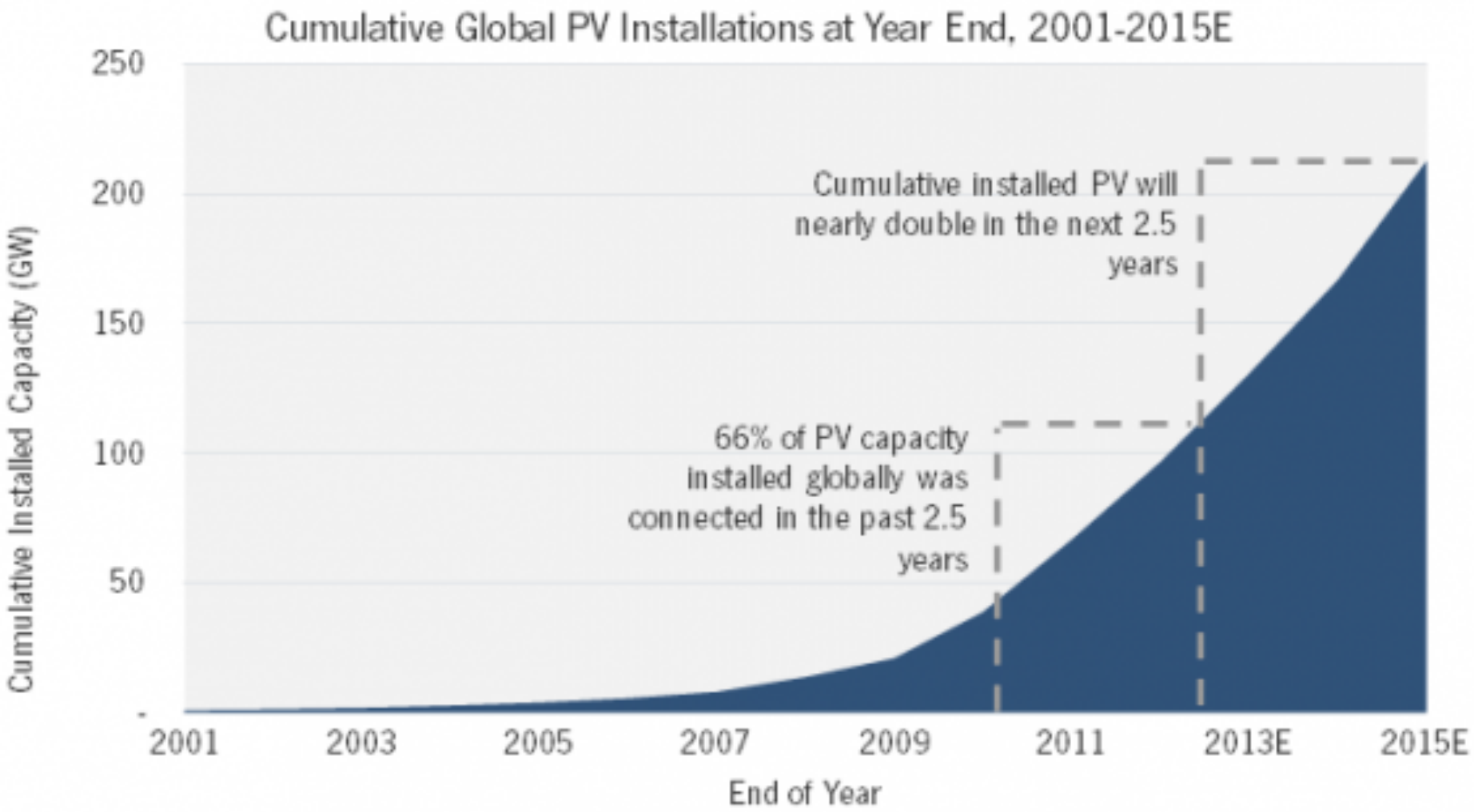
- How to get to **100%** renewables
- 24/7 power
- Baseload generation

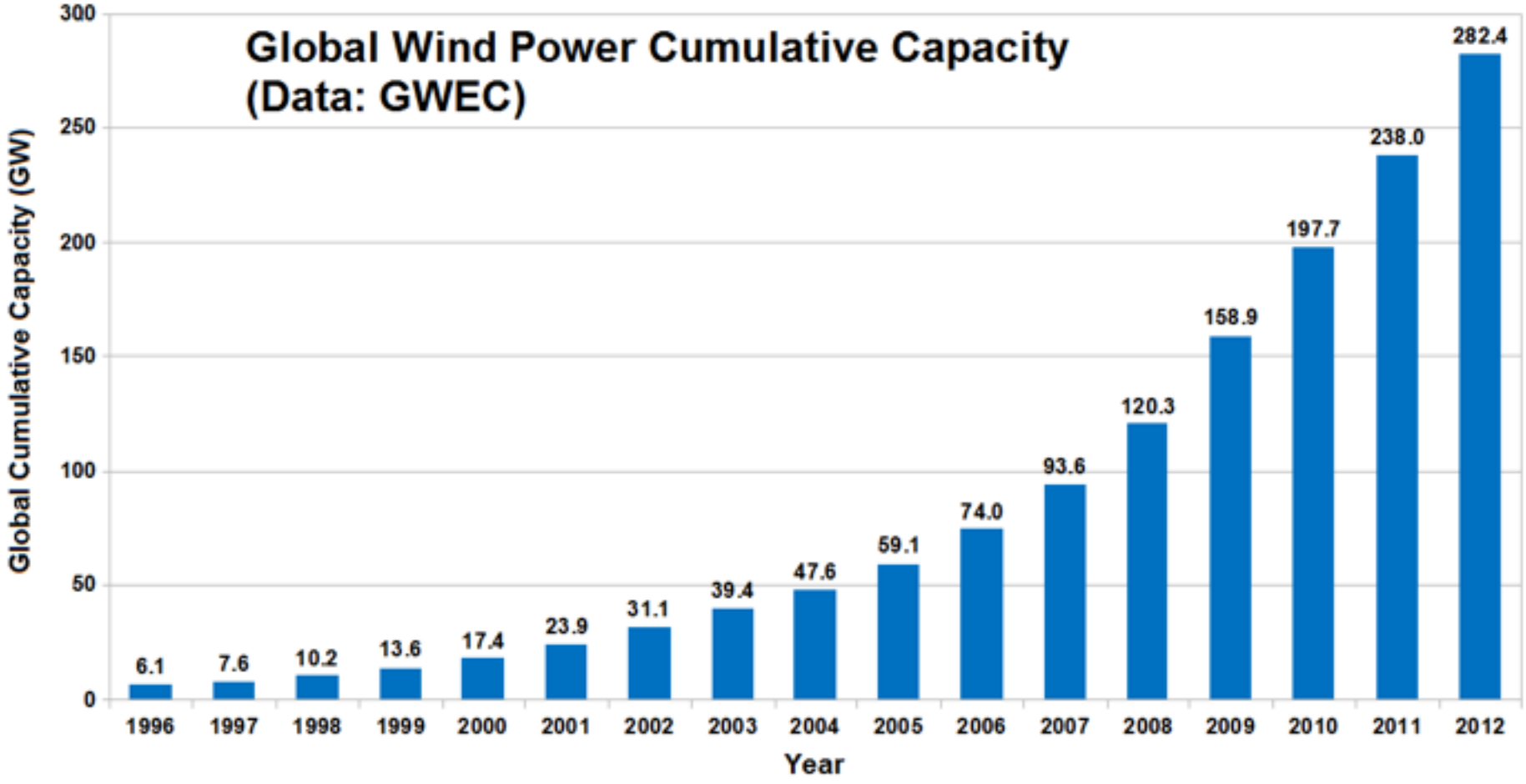
Beyond ZERO emissions

Energy

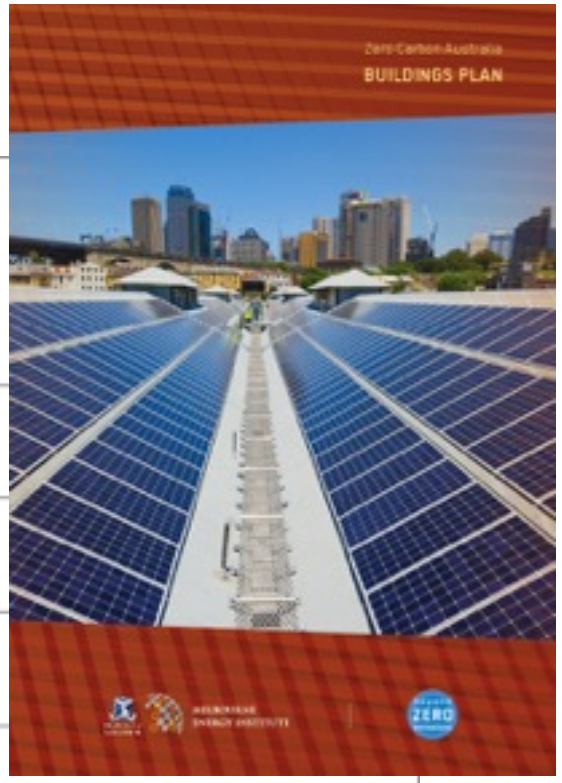
Published in 2010

Bloomberg New Energy Finance – "New wind and new solar cheaper than new coal and new gas"


Cumulative Global PV Installations at Year End, 2001-2015E
Cumulative Installed Capacity (GW)
250
200
150
100
50
-
Cumulative installed PV will nearly double in the next 2.5 years
66% of PV capacity installed globally was connected in the past 2.5 years
2001
2003
2005
2007
2009
2011
2013E
2015E
End of Year


Global Wind Power Cumulative Capacity
(Data: GWEC)
Global Cumulative Capacity (GW)
300
250
200
150
100
50
0
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59.1
74.0
93.6
120.3
158.9
197.7
238.0
282.4
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

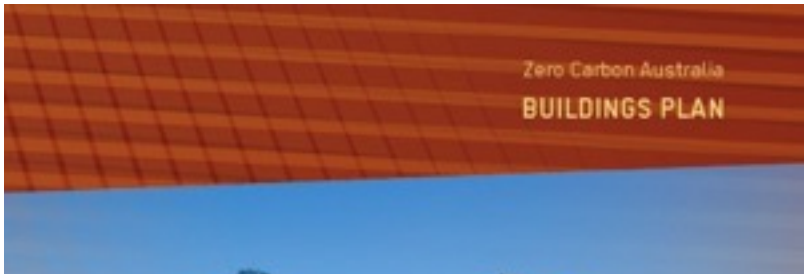
Buildings


Zero Carbon Australia
BUILDINGS PLAN

Australian CO2-e Emissions Sectors
60%
50%
40%
30%
20%
10%
0%
Stationary Energy
Agriculture & Land Use
Transport
Fugitive Emissions
Industrial Processes
Waste


Zero carbon building
230

What did we find out?



- 53% reduction in residential energy use
- 44% non-residential energy use
- 33,000MW of rooftop solar
- Initial investment offset by savings on energy bills

Buildings

Brick Veneer

Heating dominant climates

-75% energy use

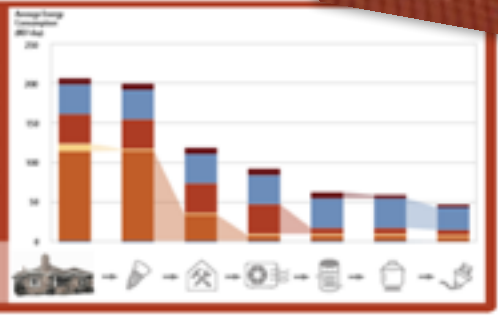
Base Building Parameters

- Building Fabric: Brick veneer wall, concrete floor, pitched tile roof
- Insulation: Ceiling only: R2.5 (added).
- Glazing: Single glazed; U - 6 W/m2K; SHGC - 0.8
- Shading: Eaves, no awnings on east or west facing windows
- HVAC: Gas heating, average performing air conditioning system

Retrofitting Modelling Location

Retrofit Modelling

The graph shows modelling results for each step of the retrofit of a brick veneer house with concrete slab in Melbourne with floor area of 165 m² which currently consumes around 206 MJ/day.
Through the retrofitting of lights, fabric upgrades, space conditioning, hot water, cooking and equipment an overall energy reduction of approximately 75% is achieved.



Lighting

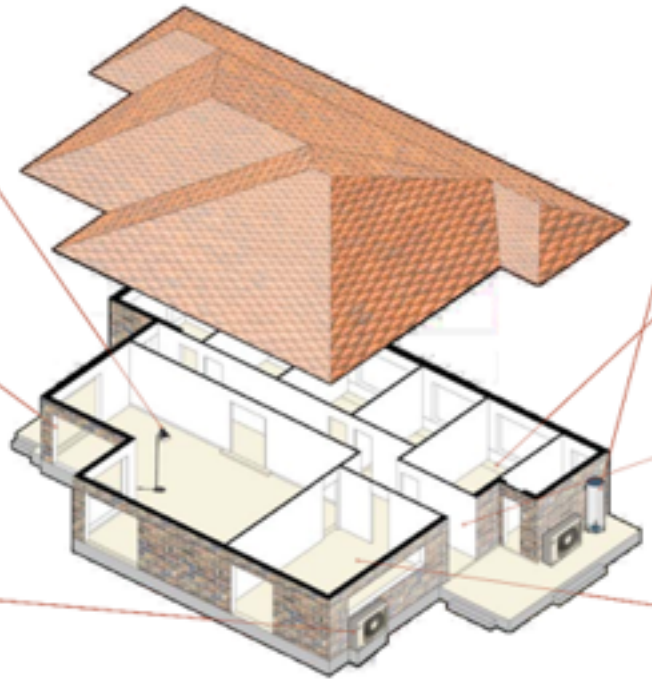
- Replace all linear fluoros and halogen downlights with LED alternatives
- Assumed efficacy of LEDs - 150 lm/W

Fabric Upgrades

- Insulate roof to R6, insulate walls to R2.5
- Replace windows with thermally broken double glazed units
- Install curtains and pelmets on all windows
- Ventilated downlights to be eliminated; install self sealing exhaust fans
- Full weather sealing on external windows and doors
- External awnings on east and west windows

Space Conditioning

- Best on the market split system reverse cycle air-conditioners to replace all gas heaters and old air-conditioners. COP >4.6
- 2 .5kW for bedroom, 4 5kW for living room
- Wood heating maintained on downward trend



Hot Water

- Heat pump to replace all gas instantaneous, gas tank, and electric tank units
- Heat Pump: COP 4
- Water efficiency measures, e.g. low flow shower head

Cooking

- Replace gas cooktops with induction electric
- Replace small amount of gas ovens with electric. (Electric is dominant type on market.)

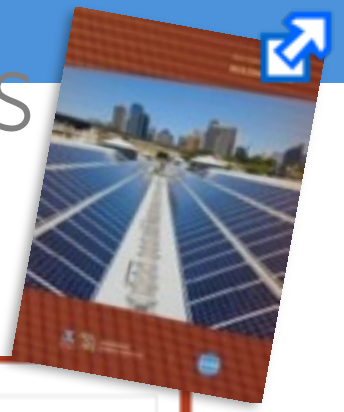
Energy Monitoring

- Installation of Smart Meter
- Installation of In Home Display or web portal for real time monitoring of energy consumption
- Meters/switches on individual appliances

Appliances

- New replacement appliances must meet best practice energy performance e.g. LED displays, best available fridge, washer, etc.

Buildings



Timber weatherboard

Cooling dominant climates

-29% energy use

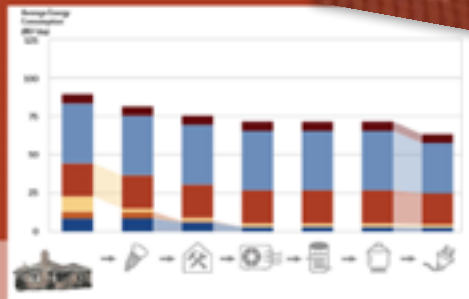
Base Building Parameters

- Building Fabric: Timber walls, timber floor,
- pitched tile roof.
- Insulation: Ceiling only - R2.5 (70% of housing stock)
- Glazing: Single glazed; U - 6 W/m2K; SHGC - 0.8
- Shading: Eaves, no awnings on east or west facing windows
- Hot Water: Electric
- HVAC: Electric heating, average performing air conditioning system

Retrofitting Modelling Location

Retrofit Modelling

The graph shows modelling results for each step of the retrofit of a timber weatherboard house in Brisbane of floor area 177m² which currently consumes around 90 MJ/day.
Through the retrofitting of lights, fabric upgrades, space conditioning, hot water, cooking and equipment an overall energy reduction of approximately 29% is achieved.



Lighting

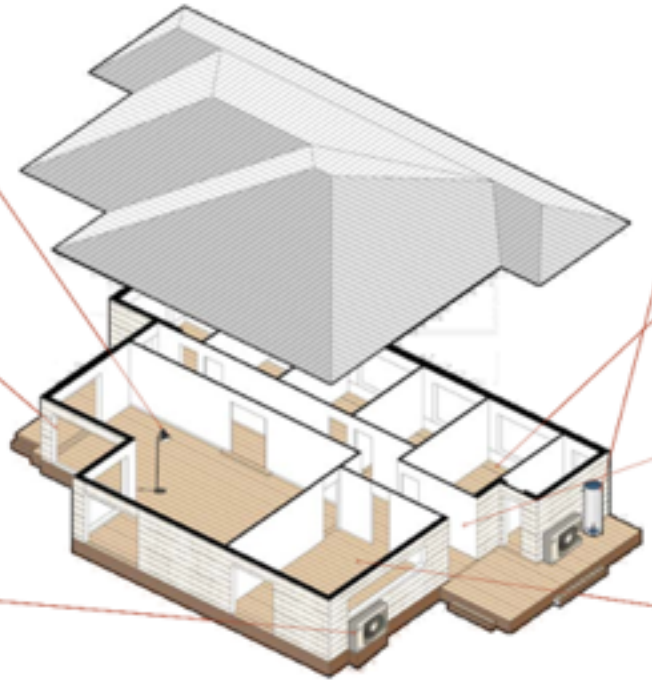
- Replace all A19 incandescent, CFL, halogen, linear fluoros, halogen downlights with LED alternatives
- Assumed efficacy of LEDs = 150 lm/W

Fabric Upgrades

- Insulate roof to R6, insulate walls to R2.5, floors R2
- Replace windows with single glazed low-emissivity IGUs with larger openings
- Ventilated downlights to be eliminated; install self sealing exhaust fans
- Full weather sealing on external windows and doors
- External awnings on east and west windows, plus north in tropical climate zones

Space Conditioning

- Best on the market split system reverse cycle air conditioners to replace all gas heaters and old air conditioners, COP >4.6
- 2-3kW for bedroom, 4-5kW for living room
- Ceiling fans for improved air circulation without air conditioner
- Wood heating maintained on downward trend



Hot Water

- Heat pump replace all gas instantaneous, gas tank units
- Heat Pump: COP 4
- Water efficiency measures, e.g. low flow shower head

Cooking

- Replace gas cooktops with induction electric
- Replace small amount of gas ovens with electric. (Electric is dominant type on market.)

Energy Monitoring

- Installation of Smart Meter
- Installation of In Home Display or web portal for real time monitoring of energy consumption
- Meters/switches on individual appliances

Appliances

- New replacement appliances must meet best practice energy performance e.g. LED displays, best available fridge, washer, etc.

Buildings

Masonry clad tower

-80% energy use

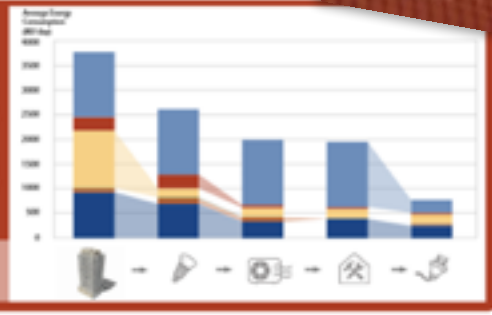
Base Building Parameters

- Building Fabric: Concrete/masonry walls, concrete slab, concrete roof
- Insulation: None
- Glazing: Single glazed: U = 5.7 W/m2K; SHGC = 0.8
- Glazing extent: 20% (punch hole windows)
- Shading: Minimal
- HVAC: Air cooled chillers, Fan Coil Unit System
- Assumed lighting power density - 17W/m2 (400 lux)

Retrofitting Modelling Location

Retrofit Modelling

The graph shows modelling results for each step of the retrofit of a pre-1945 office building in Brisbane with a net lettable floor area of 1,560m2 which currently consumes an average of 5,790MJ/day of energy.
Through the retrofitting of lights, space conditioning, fabric upgrades and appliances an overall energy reduction of approximately 80% is achieved.



Lighting

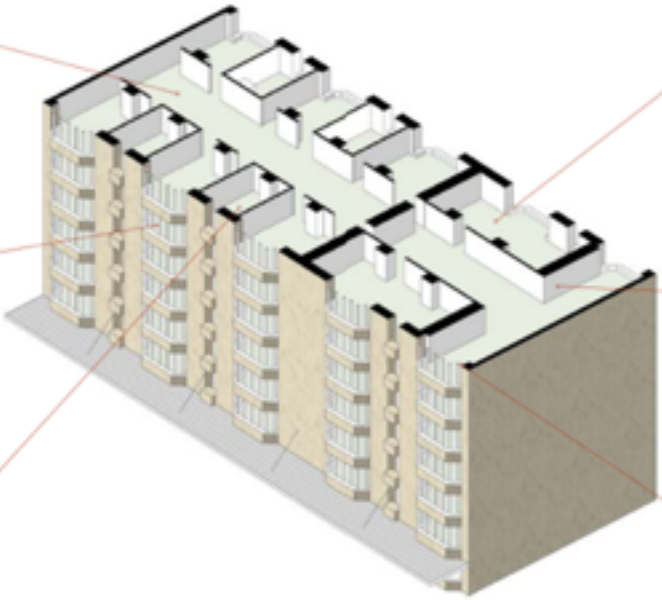
- Replace all A19 incandescent, CFL, halogen, linear fluoros, halogen downlights with LED alternatives
- Assumed efficacy of LEDs = 150 lm/W

Fabric Upgrades

- Replacement Double Glazed windows: U = 2; SHGC = 0.64
- Insulate roof to R4 and walls to R2.5
- Draught proofing/air locks reduce air infiltration: 1 ACH to 0.1 ACH

Space Conditioning

- Air cooled chiller upgrade: COP = 4 (halve energy consumption)
- Boiler replacement with heat pump: COP = 4
- Variable speed drives and controls on pumps and fans
- Night purge



Hot Water

- Heat pump to replace all gas instantaneous, gas tank, and electric tank units
- Heat Pump: COP 4
- Water efficiency measures, e.g. low flow shower head

Energy Management

- Installation of Energy Management System with sub-metering
- Provide on site Facility Managers trained in energy efficiency

Appliances

- New replacement appliances must meet best practice energy performance e.g. LED displays, low wattage PCs
- Equipment load reduction: 15W/m2 to 5W/m2
- Gas cooking replaced with high efficiency electric (where applicable)

Buildings

Curtain wall tower

-78% energy use

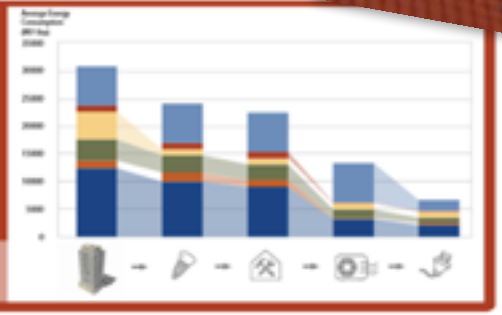
Base Building Parameters

- Building Fabric: Curtain wall, concrete slab, concrete parapet
- Insulation: None
- Glazing: Single glazed: U = 5.6 W/m2K; SHGC = 0.6
- Glazing extent:
  1945-1980 - 32% (high spandrel area)
  1980-2000 - 75% (full vision glass)
- Shading: None
- HVAC: Constant volume central ducted A/C
- Assumed lighting power density - 12W/m2 (400 lux)

Retrofitting Modelling Location

Retrofit Modelling

The graph below shows modeling results for each step of the retrofit of a curtain wall office building in Sydney built between 1980-2000 which currently consumes around 30,845MJ/day of energy.
Through the retrofitting of lights, fabric upgrades, space conditioning and appliances an overall energy reduction of 78% is achieved.



Lighting

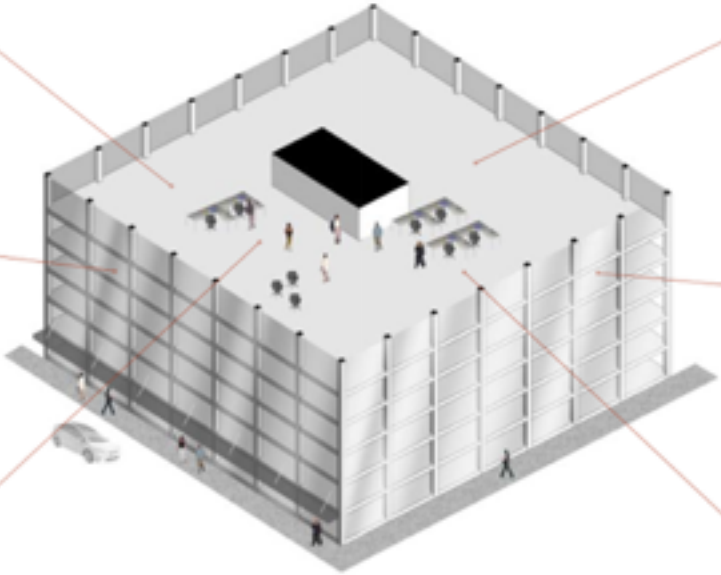
- Replace all A19 incandescent, CFL, halogen, linear fluoros, halogen downlights with LED alternatives
- Assumed efficacy of LEDs = 150 lm/W

Fabric Upgrades

- Apply solar control film. This will halve solar heat gain
- Insulate roof to R4.5 and walls to R2.5
- Draught proofing/air locks reduce air infiltration: 1 ACH to 0.1 ACH

Space Conditioning

- Water cooled chiller upgrade: COP - 6 (halve energy consumption)
- Boiler replacement with heat pump: COP - 4
- Replace constant air volume AHU with variable air volume system.
- Variable speed drives and controls on pumps and fans.
- Economy cycle (temperate climates only)
- Night purge



Hot Water

- Heat pump to replace all gas instantaneous, gas tank, and electric tank units
- Heat Pump: COP 4
- Water efficiency measures, e.g. low flow shower head

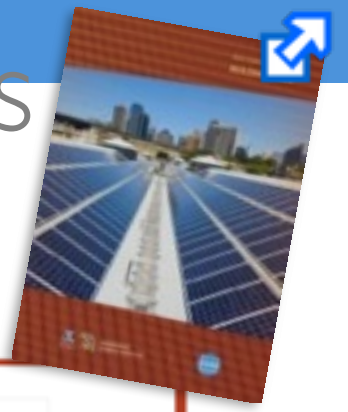
Energy Management

- Installation of Energy Management System with sub-metering
- Provide on-site Facility Managers trained in energy efficiency

Appliances

- New replacement appliances must meet best practice energy performance e.g. LED displays, low wattage PCs
- Equipment load reduction: 11W/m2 to 3W/m2
- Gas cooking replaced with high efficiency electric (where applicable)

Buildings



Shopping centre

-63% energy use

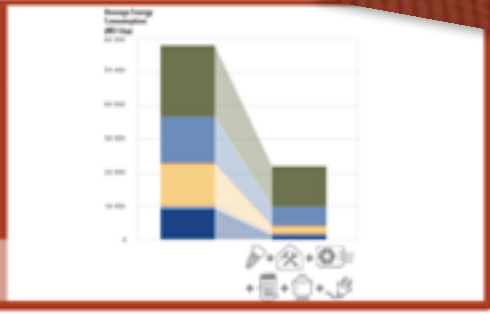
Base Building Parameters

- Building Fabric: Concrete wall, concrete slab on ground, flat metal deck roof
- Insulation: roof R1.43, wall R1.26
- Glazing: Single glazed: U = 5.69 W/m2K; SHGC = 0.61
- Skylights: U = 6.87 W/m2K; SHGC = 0.83
- HVAC: Rooftop Packaged Units. Chiller COP 2.3; gas boiler efficiency 75%
- Assumed tenancy lighting power density - 35W/m2 (800 lux)

Retrofitting Modelling Location

Retrofit Modelling

The graph shows modelling results for the retrofit of a shopping centre in Sydney with a net lettable area of 5,850m2 (of which 2,500m2 is supermarket) which consumes an average of 58,000MJ/day. Through the retrofitting of the supermarket, equipment, hot water service, lights, fabric upgrades, space conditioning, energy management systems and appliances an overall energy reduction of approx. 63% is achieved.



Lighting

All areas:
- Replace all A19 incandescent, CFL, halogen, linear fluoro, halogen downlights with LED alternatives
- Assumed efficacy of LEDs = 150 lm/W

Fabric Upgrades

Common areas:
- Apply solar control film. This will halve solar heat gain
- Insulation - Roof R4, Wall R2
- Cool Roof paint
- Draught proofing/air locks to reduce air-infiltration

Space Conditioning

Small retail:
- Replacement high efficiency air conditioner, COP 4.6

Common areas:
- New air-cooled packaged chiller COP 4 (halve energy consumption)
- Boiler replacement with heat pump COP 4
- Variable speed drives and controls on pumps and fans
- Economy cycle (temperate climates only)

Hot Water

- Heat pump to replace all instantaneous and tank units
- Heat Pump: COP 4
- Water efficiency measures, e.g. low flow shower head

Energy Management

- Installation of Energy Management System with sub-metering
- Provide on-site Facility Managers trained in energy efficiency

Appliances

- New replacement appliances must meet best practice energy performance e.g. LED displays, low wattage PCs
- Gas cooking replaced with high efficiency electric (where applicable)

Supermarkets

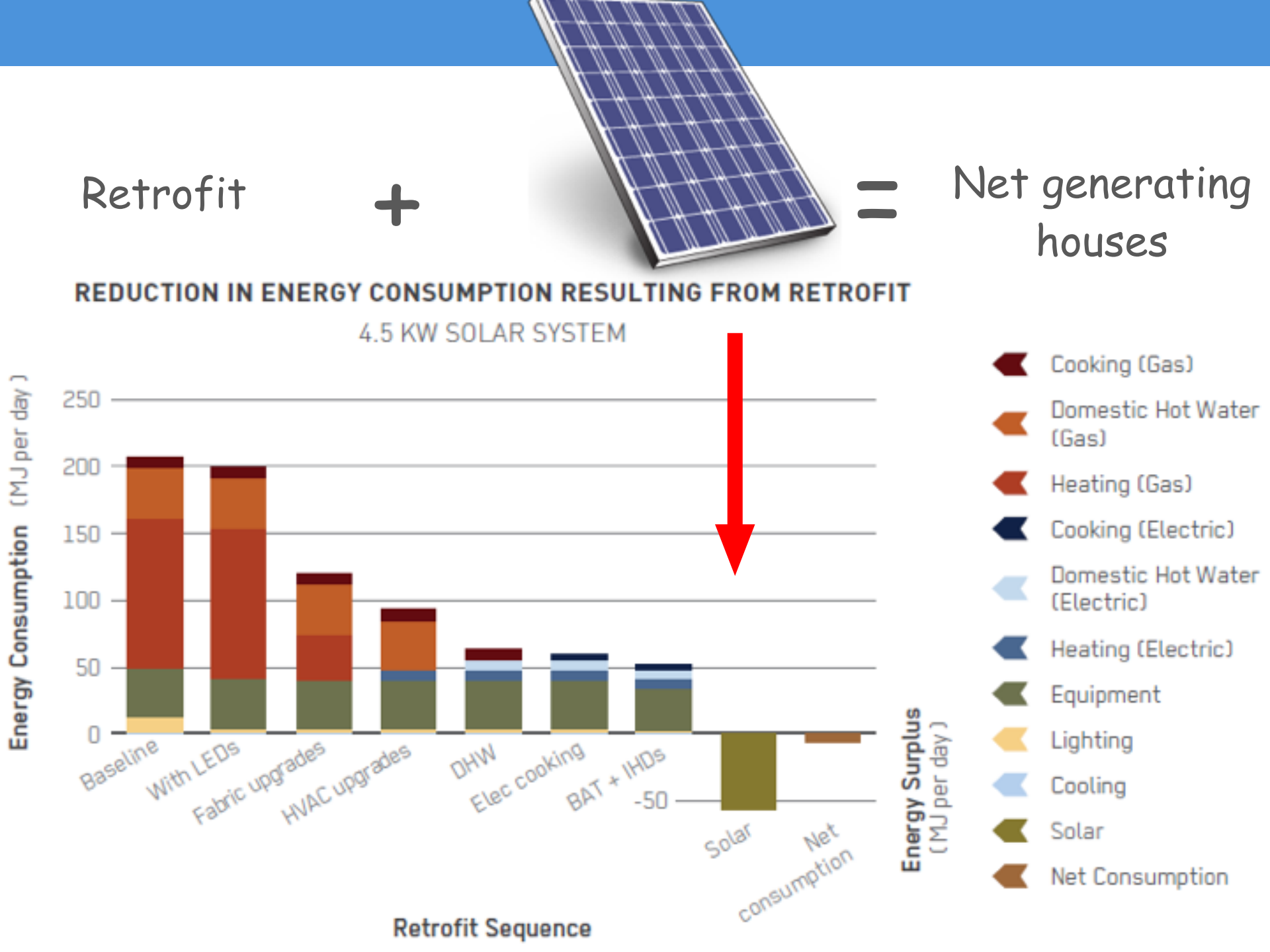
- Fit doors on display cases - triple glazed with controls to minimise anti-sweat heater energy demand
- All other cost effective measures already implemented in best performing 20% of large supermarket chains
- Total energy demand reduction from 820 kWh/m² to 500 kWh/m²

energyfreedom.com.au

1. LED lighting upgrades
2. Insulation upgrades
3. Efficient electrical appliances
4. Induction cooktops
5. Double glazing
6. In-home displays
7. Heat pump space conditioners
8. Heat pump hot water
9. Rooftop solar

Plus energy retailer switch

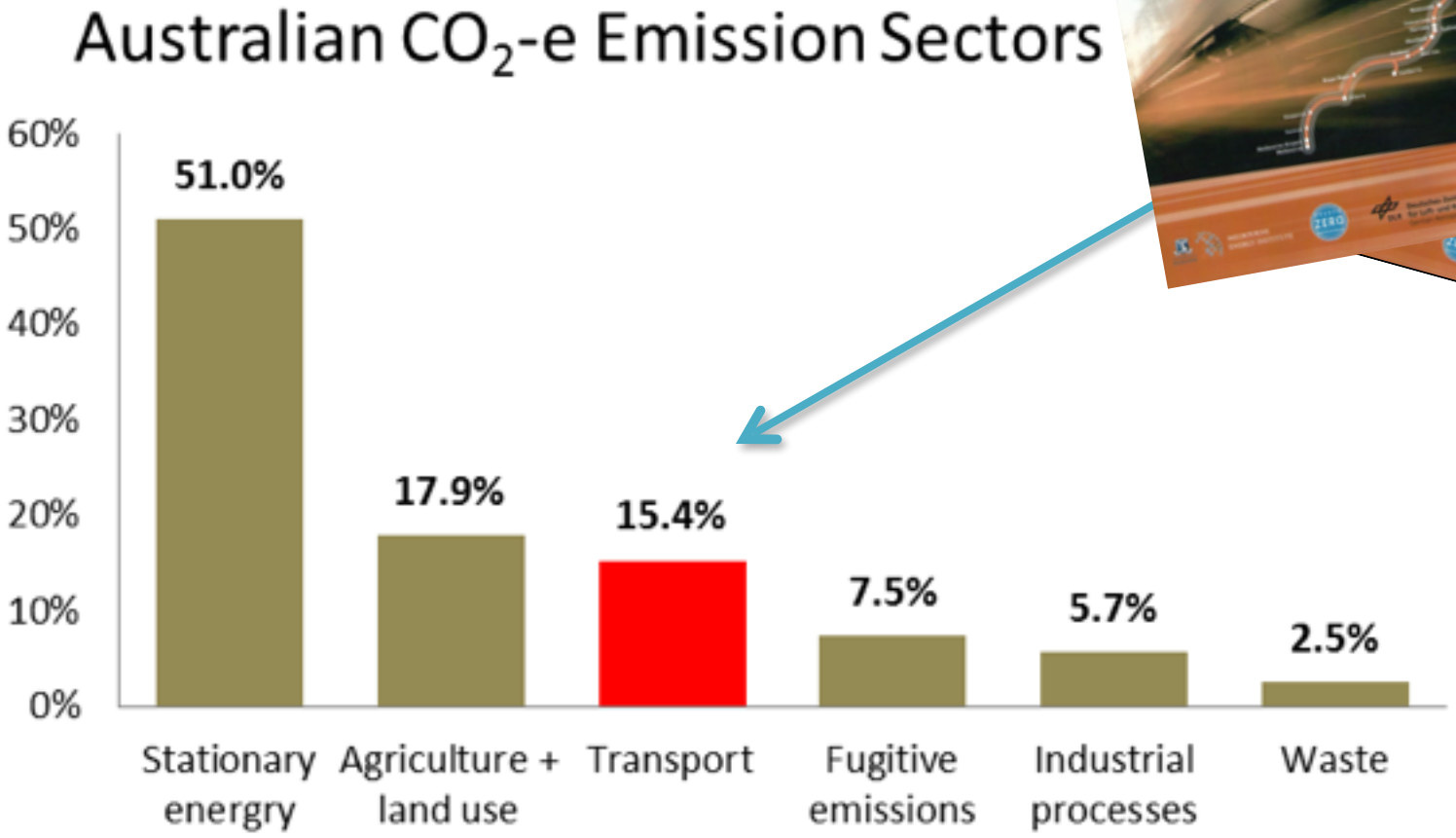
Retrofit + = Net generating houses



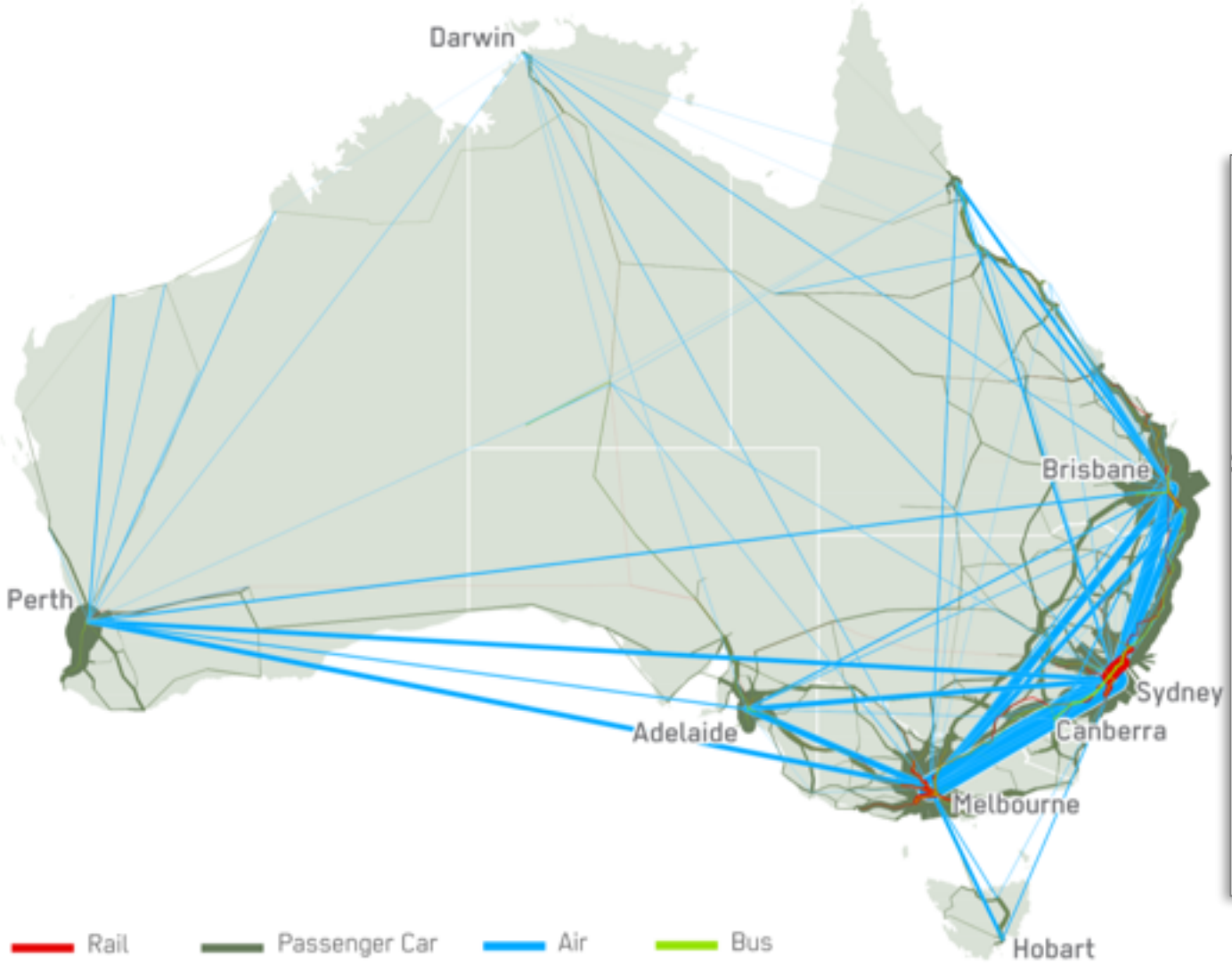
Homes become solar power stations
energyfreedom.com.au

Transport


Zero Carbon Australia
High Speed Rail


Australian CO_2-e Emission Sectors
60%
50%
40%
30%
20%
10%
0%
51.0%
17.9%
15.4%
7.5%
5.7%
2.5%
Stationary energy
Agriculture + land use
Transport
Fugitive emissions
Industrial processes
Waste


Zero Carbon Australia
High Speed Rail
beyond ZERO emissions
DLR
Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center
MELBOURNE
ENERGY INSTITUTE



Beijing - Shanghai

25 million people
1,000 km

San Francisco – Los Angeles

4.7 million people
560 km

Madrid - Barcelona

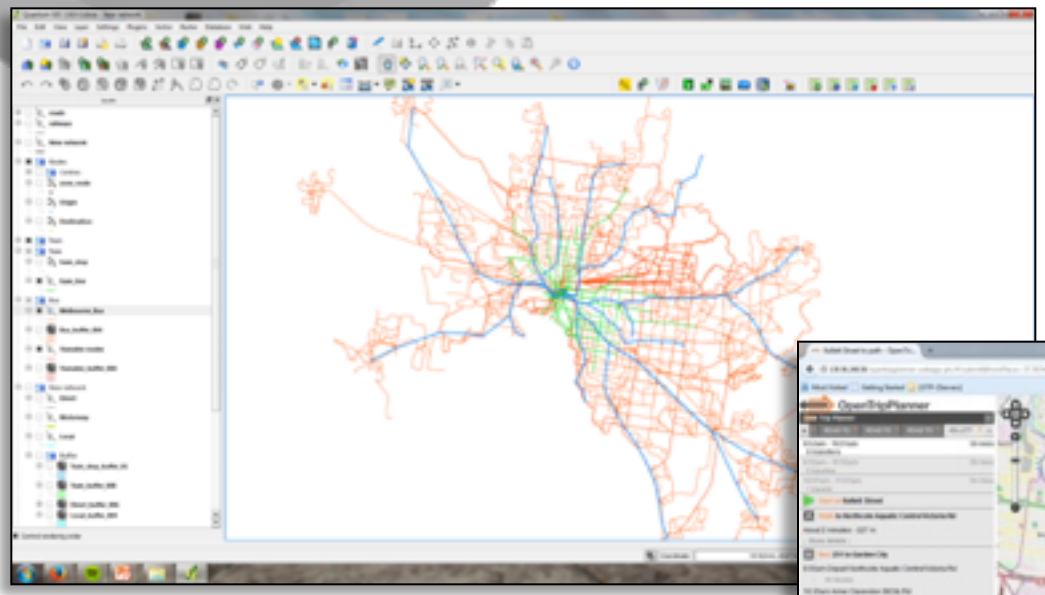
4.8 million people
500 km

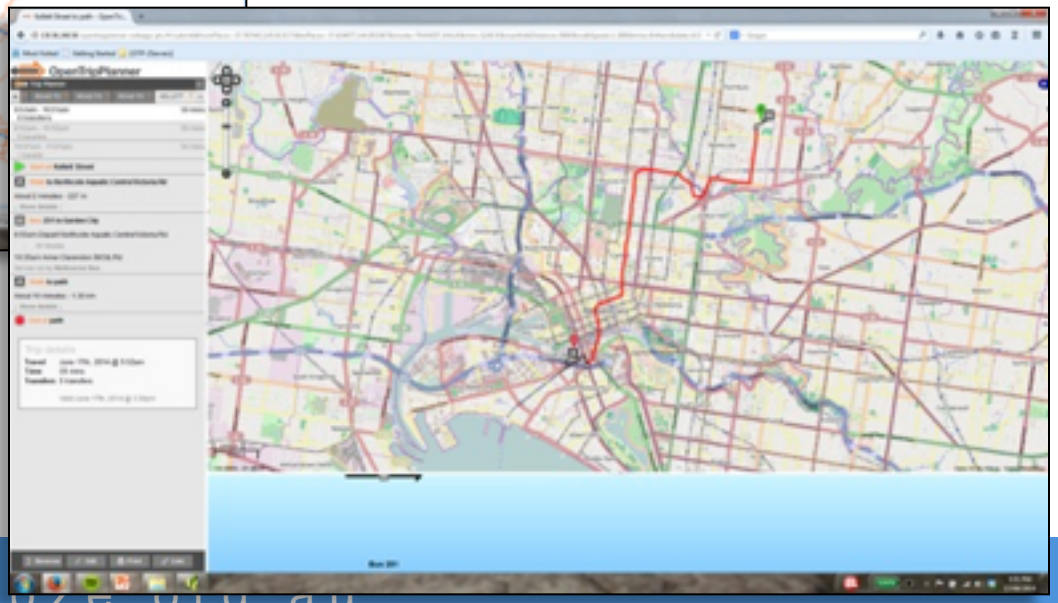
Beyond ZERO emissions

Transport

transit

- Standardised platform
- Rapid concept development
- Public interaction





QUANTUM GIS

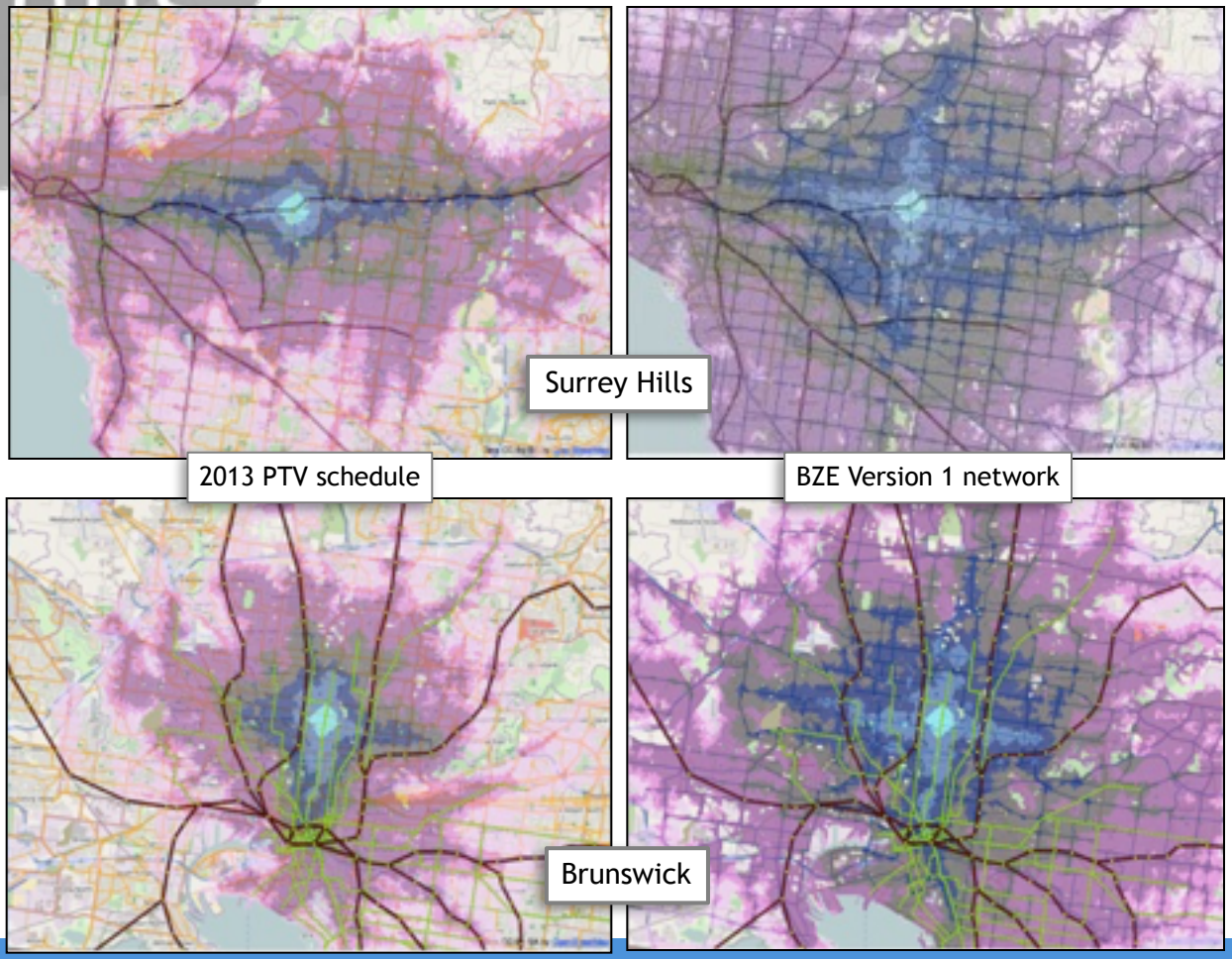
GTFS

OpenTripPlanner

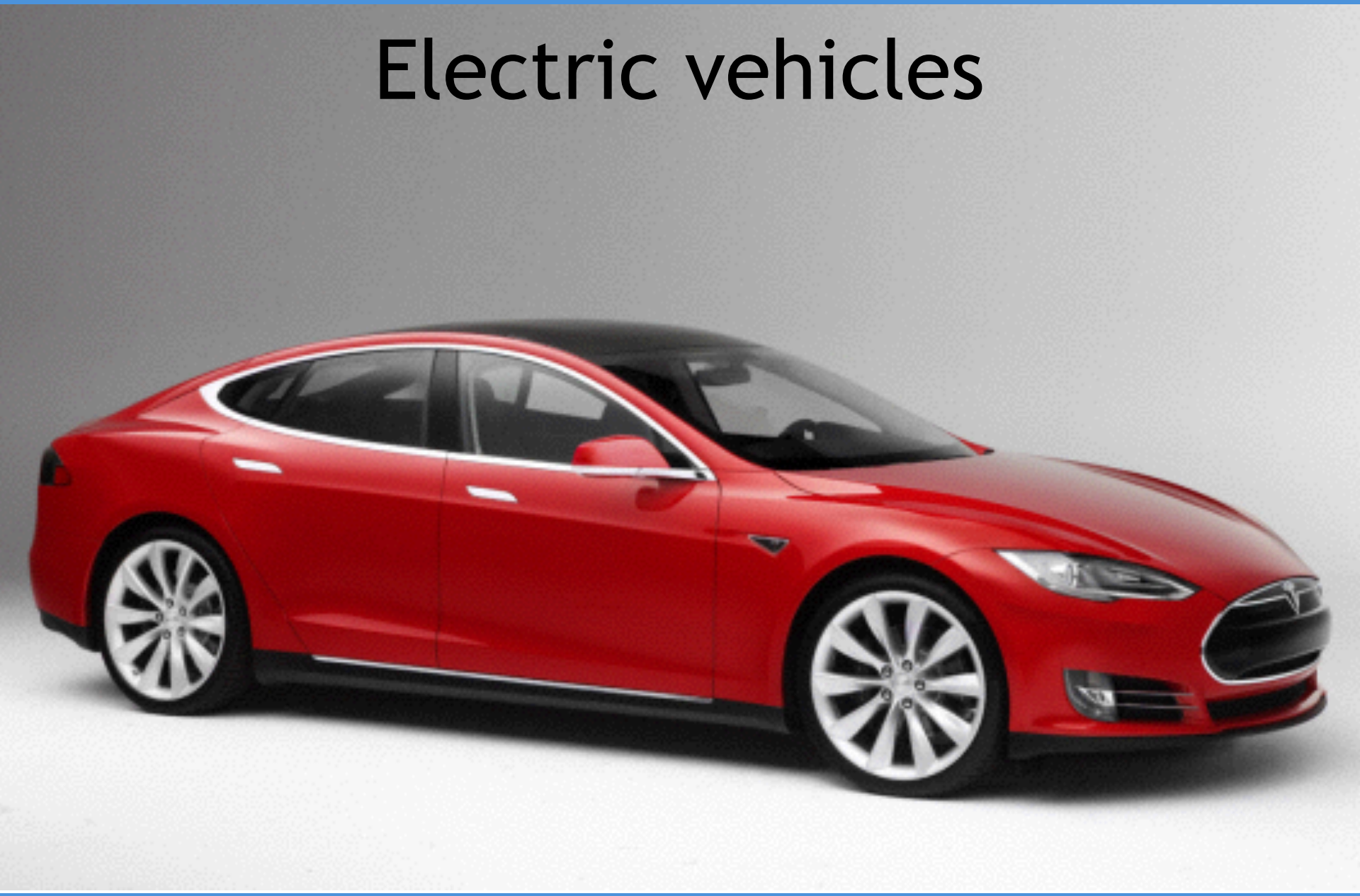
Beyond ZERO emissions

Transport

transit



Electric vehicles



Australian Transport

In 2011

Consumed

49 Billion

Litres oil based fuel

Australian Government
Department of Resources, Energy and Tourism

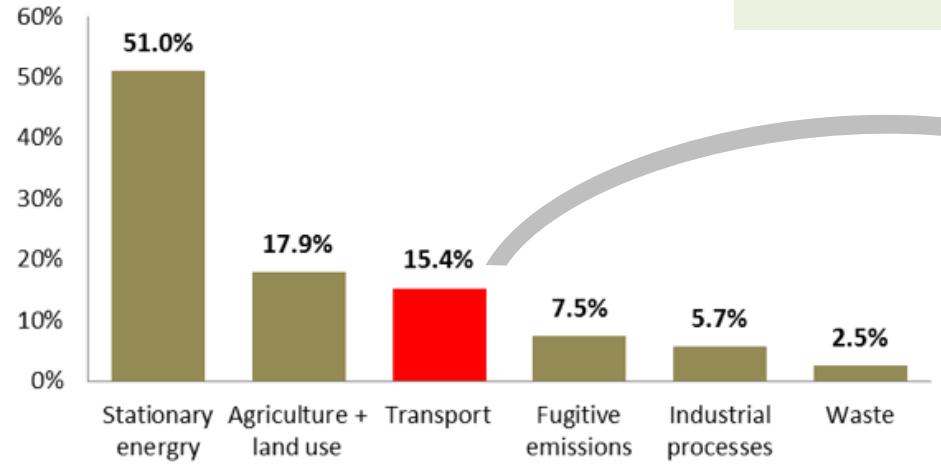
Emitted

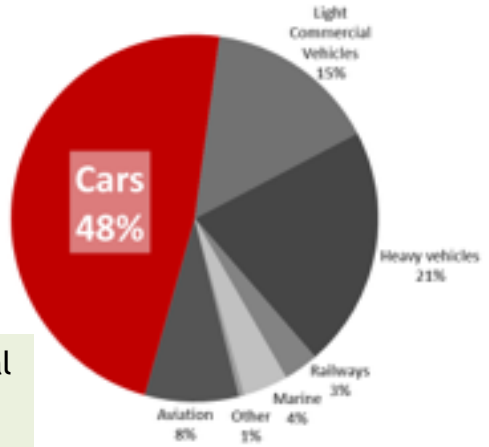
87.6 Million

Tonnes CO_2-e

Australian Government
Department of Climate Change

Australian CO_2-e Emission Sectors





7.4% of total emissions

Electric Vehicles: economic transition

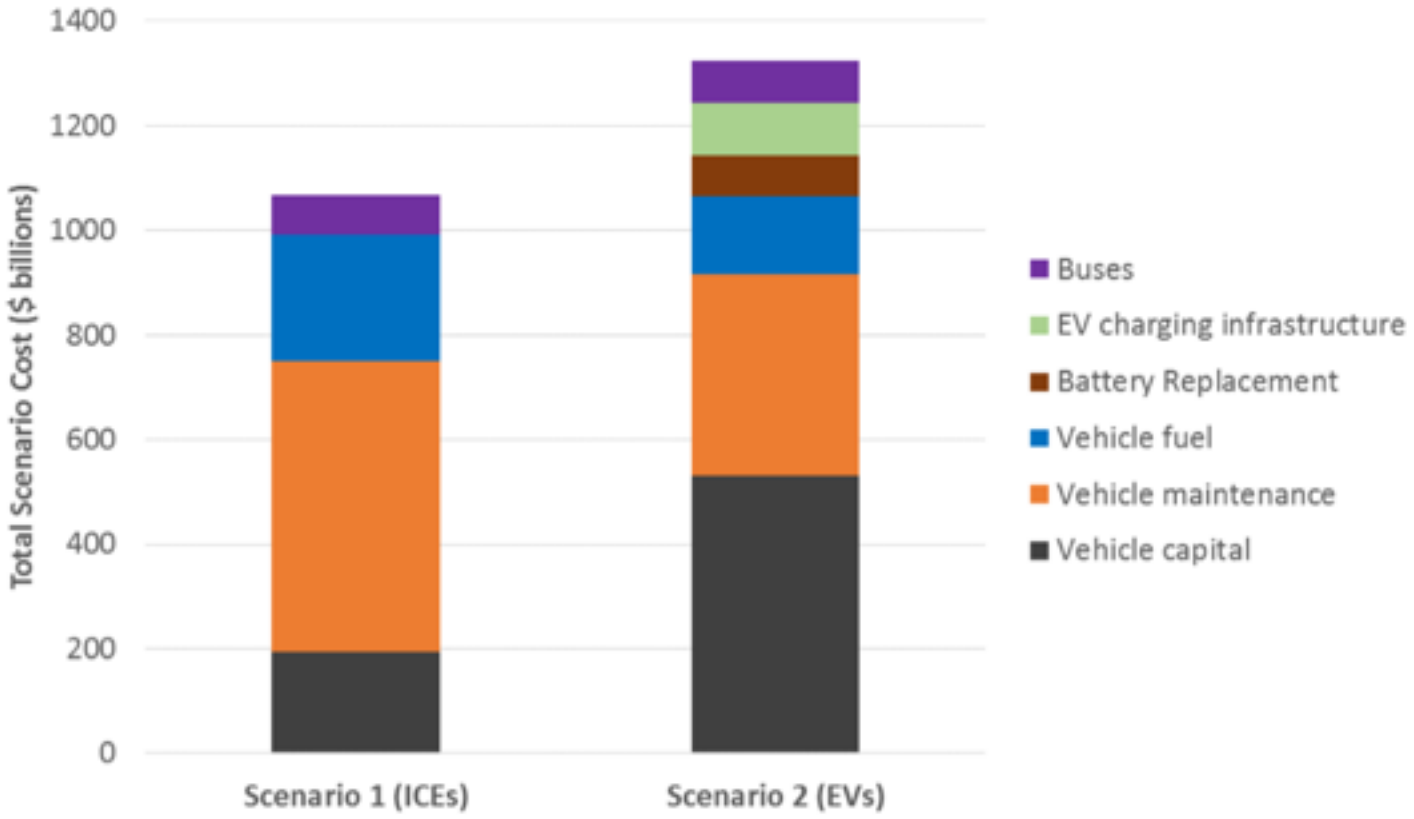


Figure 1 - Summary of Scenario costs (Net Present Value of total cost between 2015 and 2035) in the Conservative Sensitivity

Electric Vehicles: economic transition

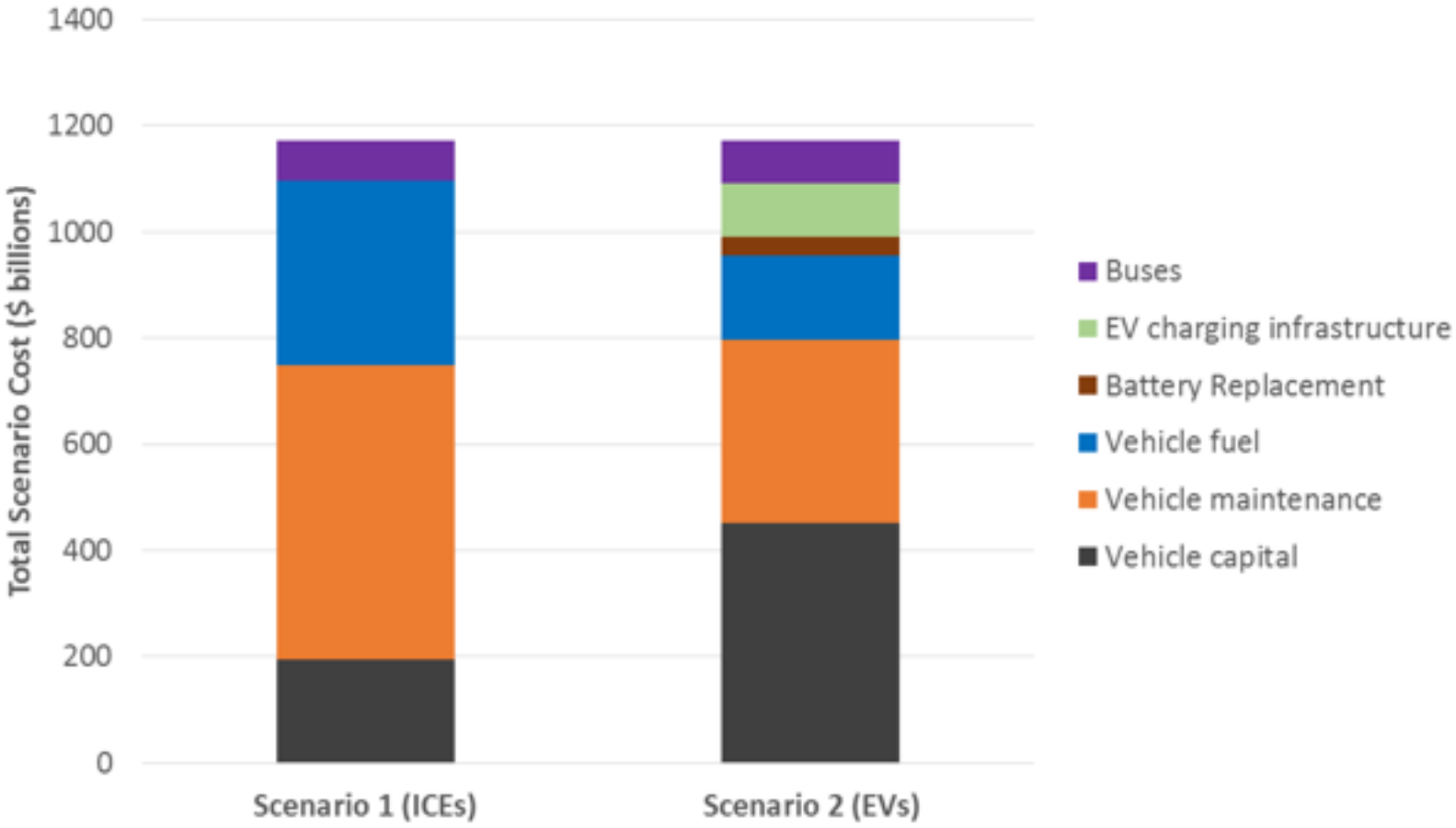
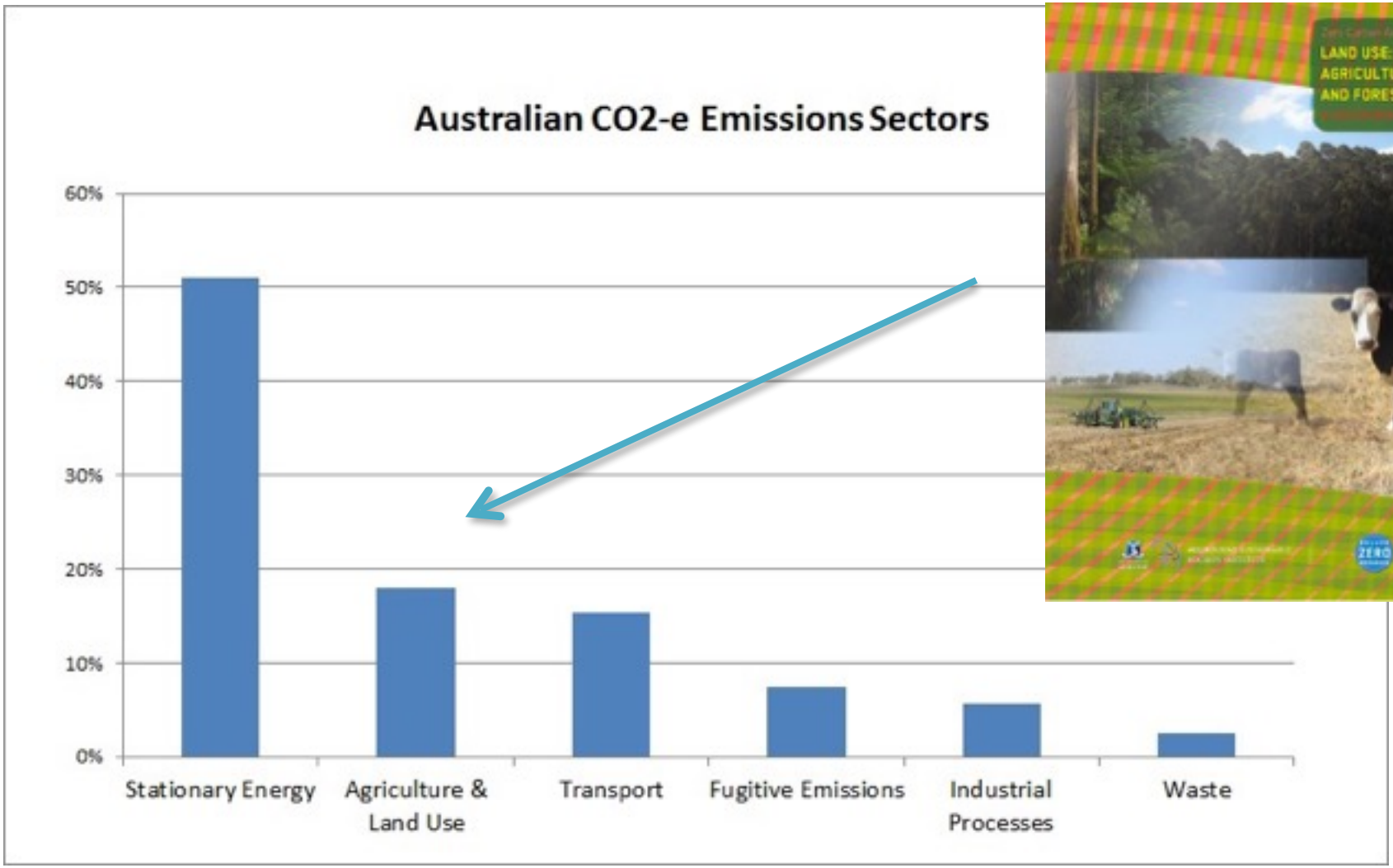


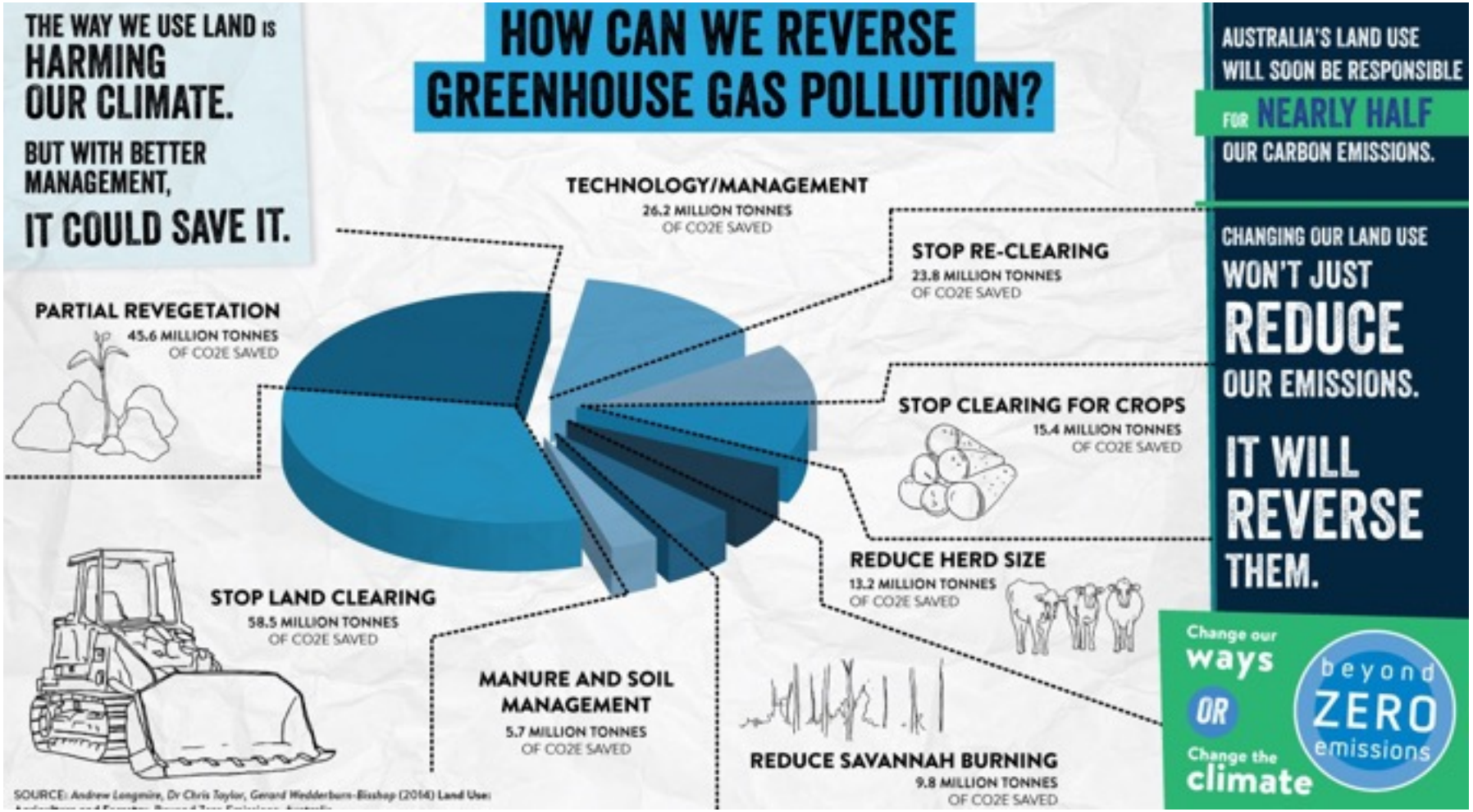
Figure 2 - Summary of Scenario costs (Net Present Value of total cost between 2015 and 2035) in the Low Cost Sensitivity

Land Use


Australian CO2-e Emissions Sectors
60%
50%
40%
30%
20%
10%
0%
Stationary Energy
Agriculture & Land Use
Transport
Fugitive Emissions
Industrial Processes
Waste

LAND USE:
AGRICULTURE
AND FORESTRY

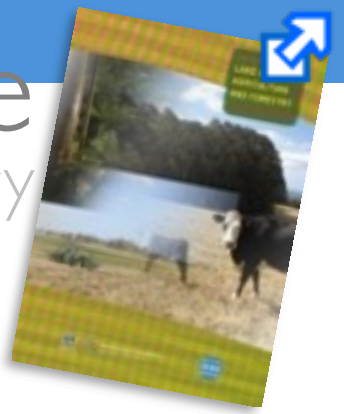
Land Use: key findings



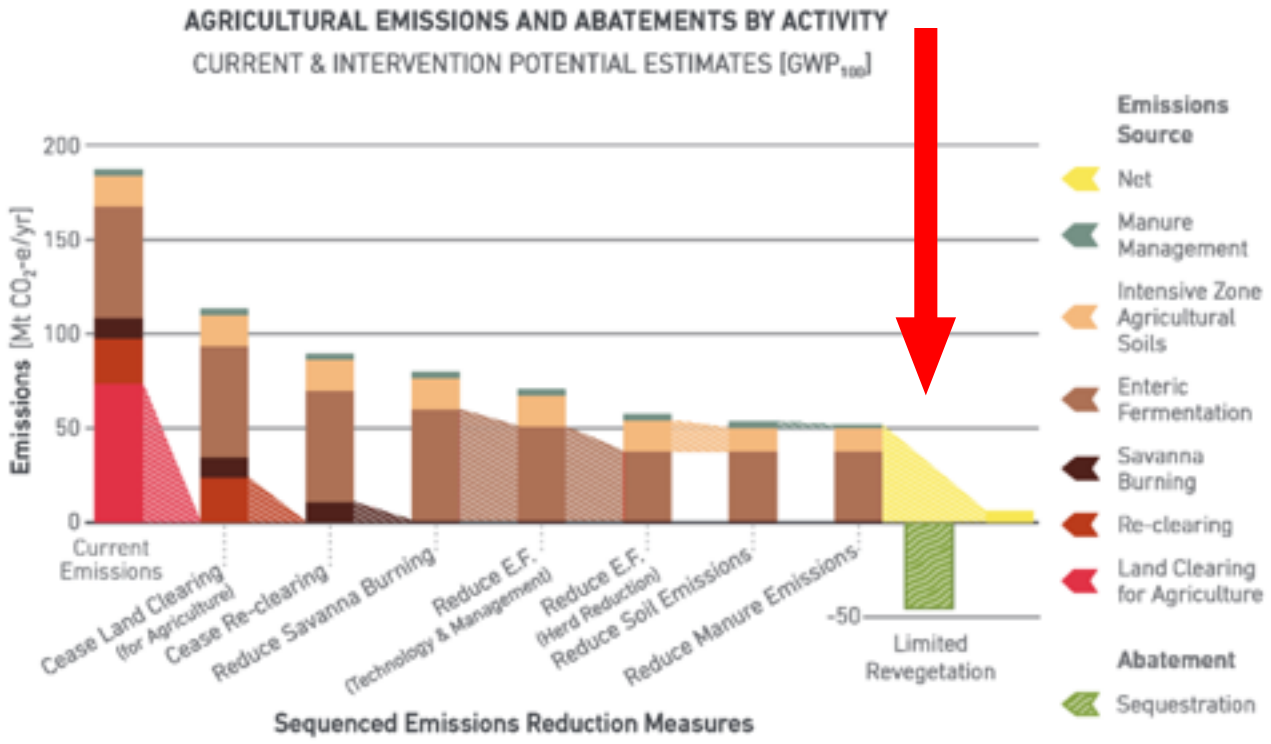
Beyond ZERO emissions

Land use

Agriculture and forestry



Emission reductions +  = Zero Emissions Agriculture

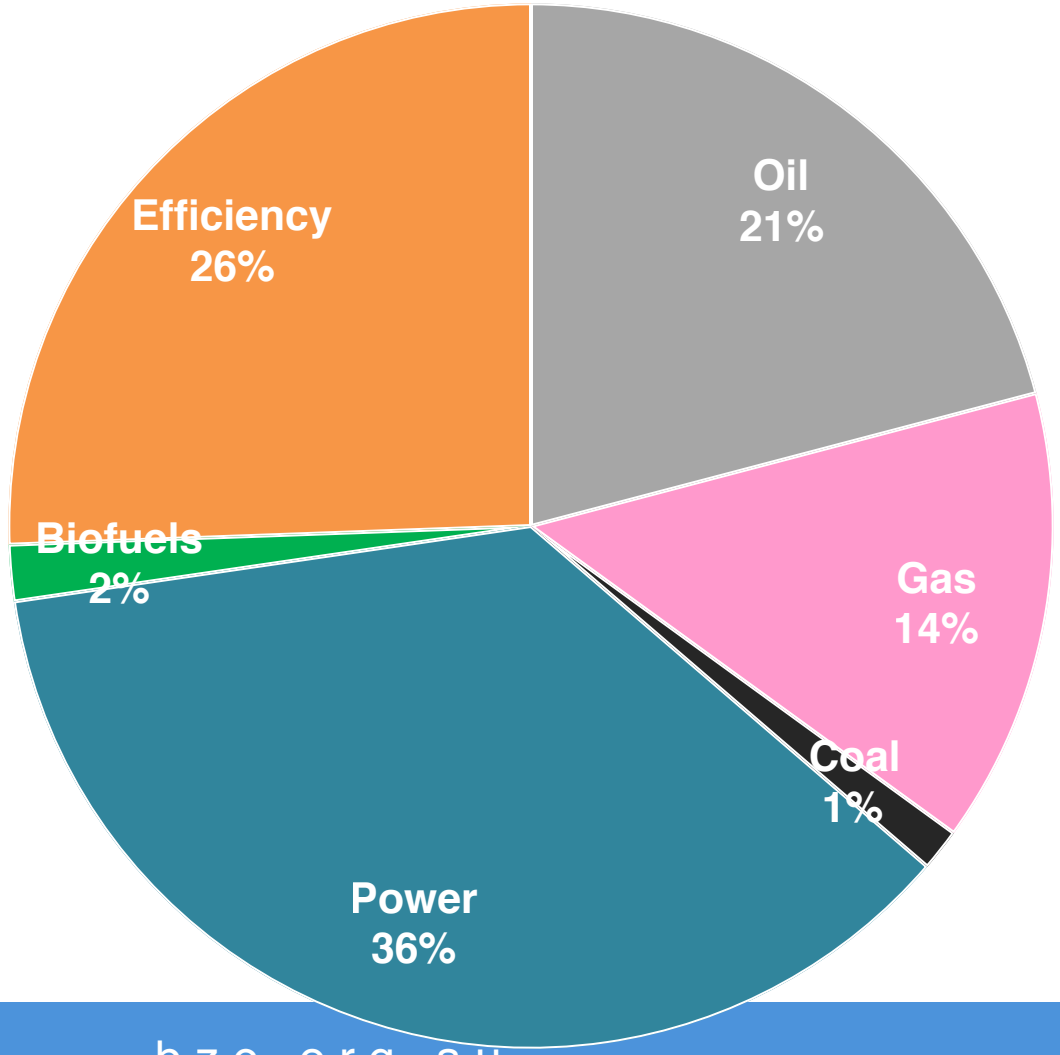


The build out

Investment:
US$53 trillion

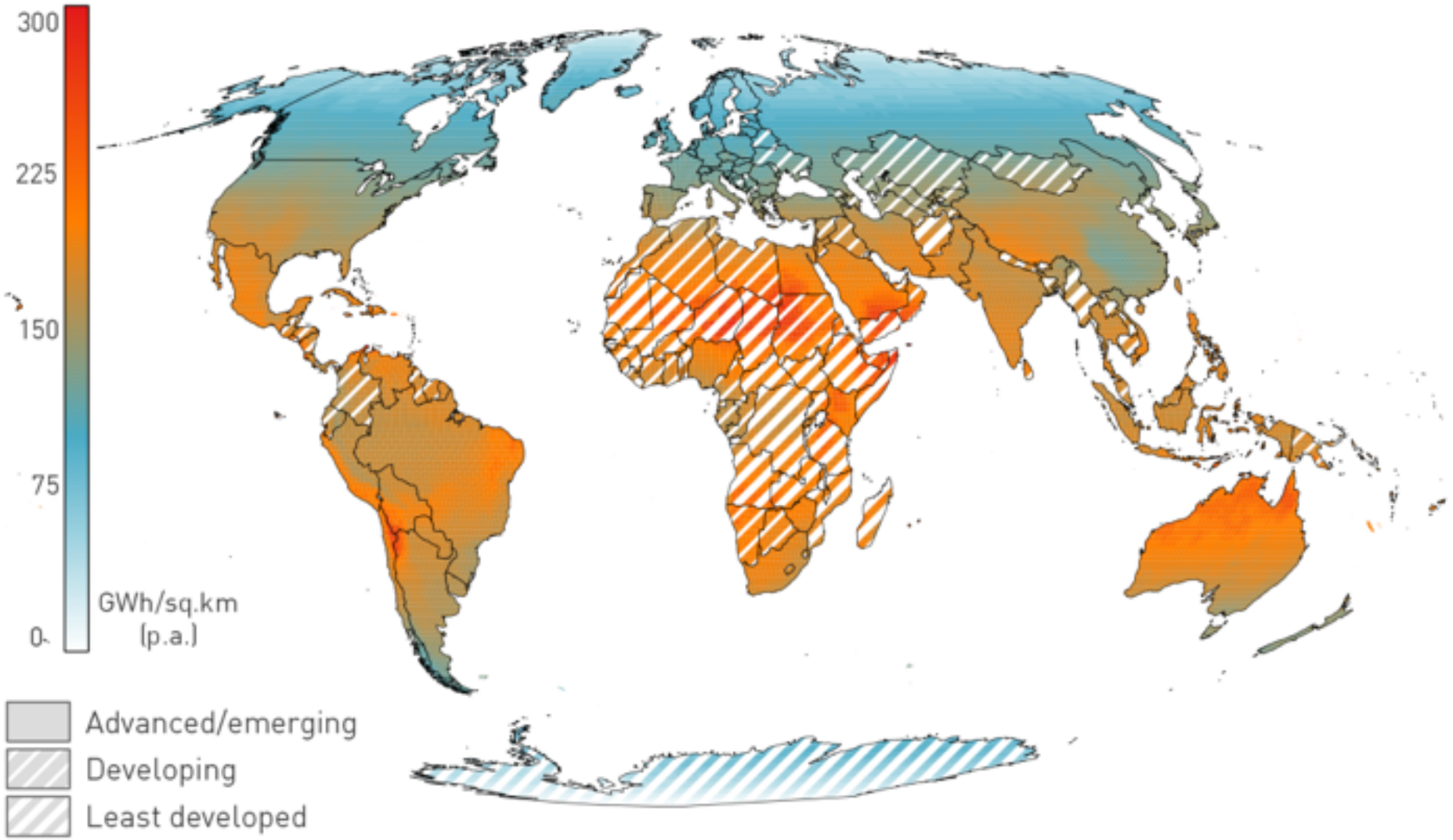
Renewables, Electricity systems, Energy efficiency.
55%

Coal
1%



IEA 450ppm scenario

Combined wind and solar generating potential



Electrify

Independent energy

Better resource, cheaper power

Energy Intensive: easy for some and hard for others

More information

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