Transitioning to Zero-Carbon Housing: Hybrid Buildings and Standards

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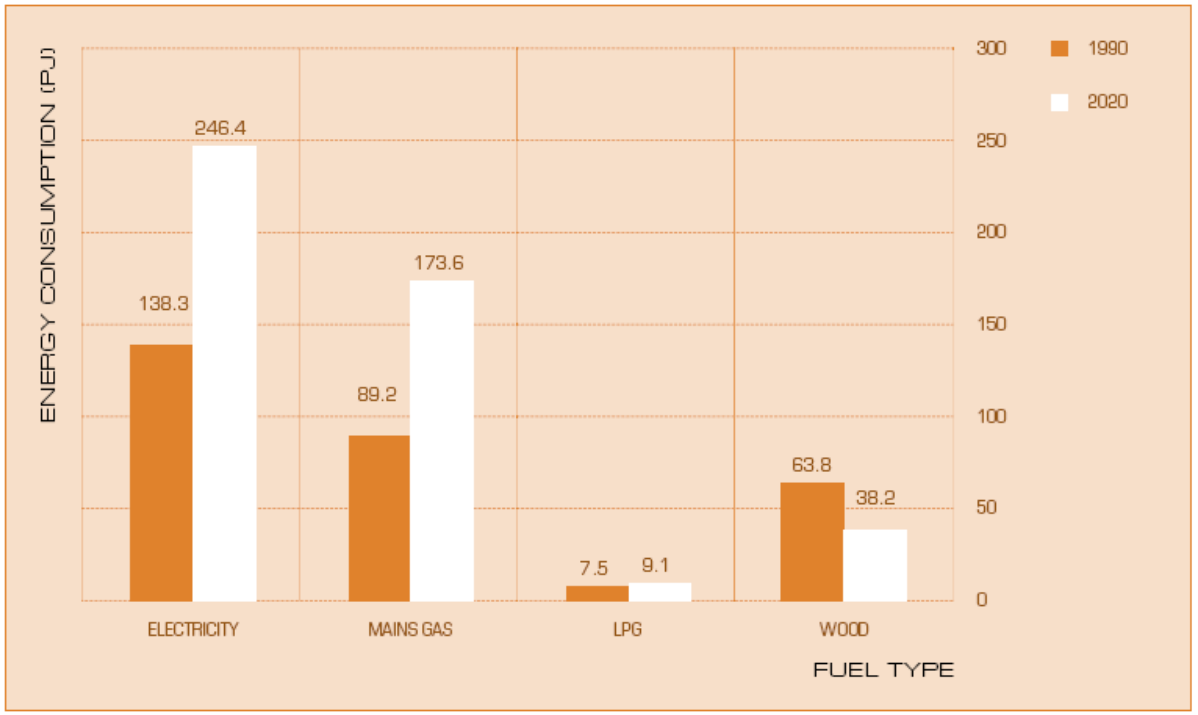
OUTLINE OF PRESENTATION

- Background
- Hybrid Building Concept and Definition
- Context – Drivers for Carbon Transition in Housing Sector
- Building Shell, Building Type and Floor Area
- Domestic Appliances
- Local/Distributed/Embedded Energy Generation
- Hybrid Building Scenarios : Transition Pathways to Zero-Carbon
- Technical Innovation vs. Behaviour/Lifestyle
- Conclusions, Barriers to Change

HYBRID BUILDING: RESPONSE TO TWO KEY 21st CENTURY CHALLENGES

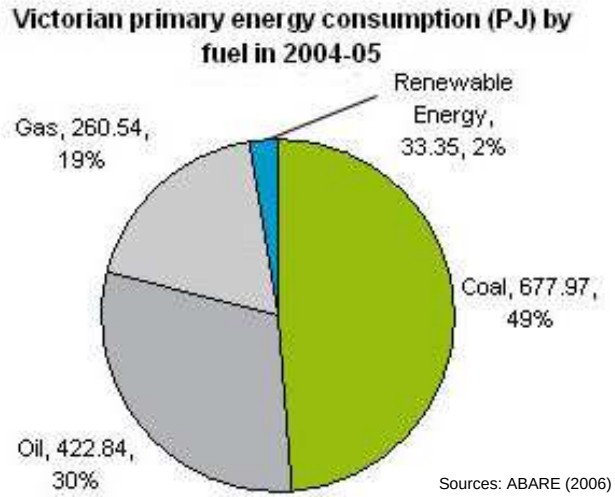
- **Energy security/Resilience**
  energy FROM the built environment; reduces dependence on non-renewable fossil fuel resources (e.g. gas) and wasteful centralised energy generation (coal-electricity) and distribution
- **GHG Mitigation and Climate Change**
  preventing CO_2 concentrations reaching 500ppm by 2100 (equates to temperature rise of 4°Celsius); in context of continued growth in energy consumption

FORECASTS IN GROWTH OF ENERGY CONSUMPTION



Sources: DEWHA (2008), Figure 6

ENERGY GENERATION AND USE



> Australia's Mandatory Renewable Energy Target (MRET) : 20% electricity supply from renewables by 2020

GHG MITIGATION IN THE AUSTRALIAN HOUSING SECTOR

Housing sector currently excluded from Federal CPRS:

*savings from housing/community interventions will "subsidise big industrial polluters"

*locks in poor performance (of dwellings) and wasteful behaviour (by households)

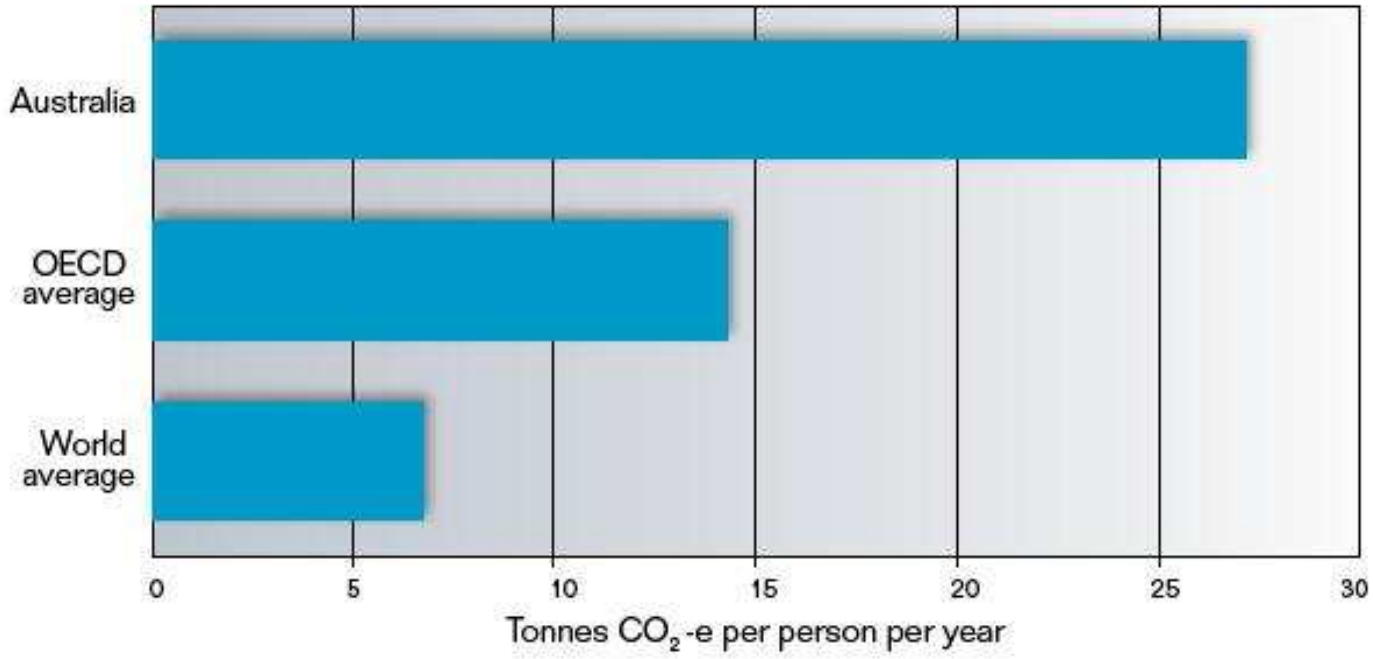
- McKinsey (2008) identified buildings as representing 6 of top 7 targets in order of least-cost CO_2 abatement
- Multiple international initiatives for GHG reduction in housing sector e.g.

  UK Community & Local Government (2006) regulation for zero carbon homes for all new construction by 2016: "zero net emissions of CO_2 from all energy use in the home"

  IEA Net Zero Energy Building Project

  Canada: Net Zero Home Coalition 2009

GHG EMISSIONS



Sources: DCC (2008) and IEA (2007)

HYBRID BUILDING : DEFINITION

Hybrid Buildings Defined

Hybrid buildings are defined here as residential buildings which have the capacity to supply, in total, the annual operating energy requirements of their occupants by providing locally generated (low or zero emission) energy to the grid at times of generating energy surplus to its occupants' immediate demands and receiving energy back from the grid if the dwelling is unable to generate sufficient energy for autonomous operation. Operating energy includes energy for heating, cooling, lighting and domestic appliances (built-in and plug-in). Local energy is supplied by a number of distributed generation technologies, both low-emission and zero-emission.

HYRBRID BUILDING

Energy Efficient Building Shell

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Energy Efficient Appliances

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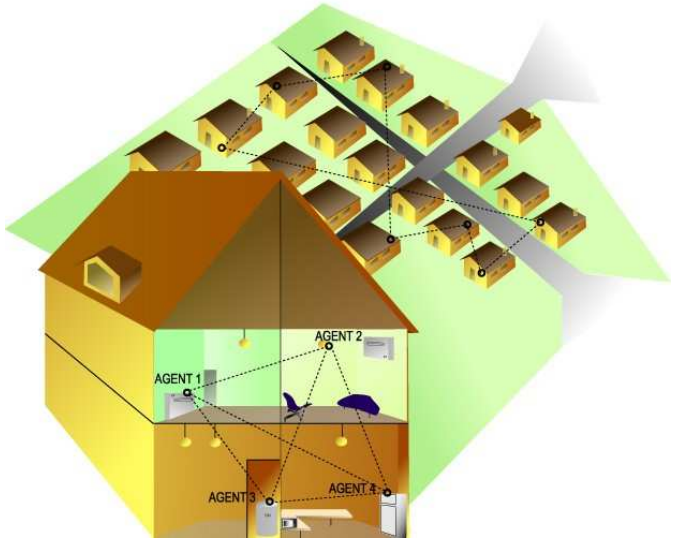
Local Energy (Distributed/ Embedded) Generation



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Hybrid Building

+

Link to National Energy Grid

HYBRID BUILDING : ENERGY & CARBON TRANSITIONS

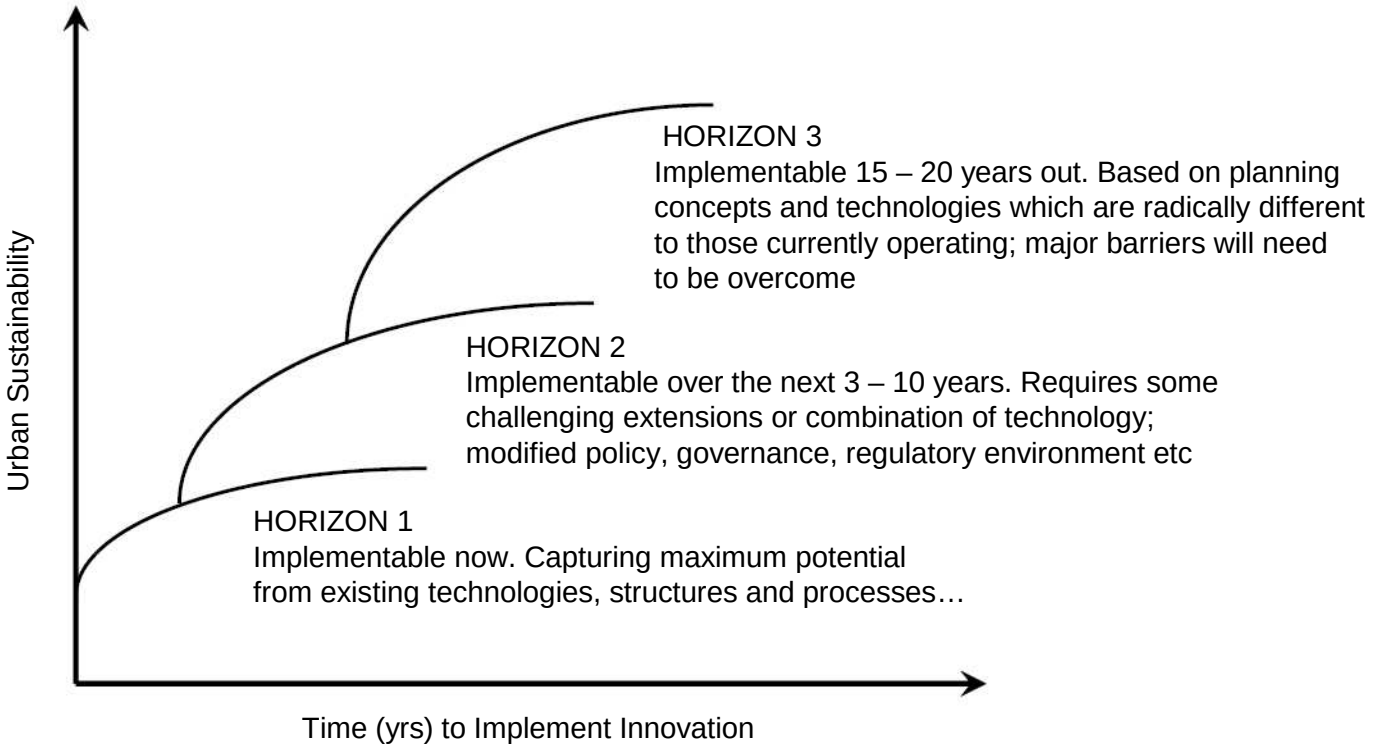
Net zero energy building supplies as much energy to the grid over the course of a year as it uses, without any reference to carbon emissions. This class of building does not preclude use of low emission local energy generation technologies.

Carbon neutral building generates sufficient surplus CO_2-e free energy over the course of a year that balances any purchase of grid energy (primarily fossil fuel based). This recognises the fact that a single dwelling/household may be unable or unwilling to generate sufficient CO_2-e free energy to be classed as zero-carbon.

Zero carbon building uses carbon free energy over the entire year, sufficient in quantity to supply all household energy needs (both dwelling operations and appliances to match any lifestyle). Connection to grid is primarily in order to supply energy that is surplus to household needs, and for periods of emergency supply when local energy system may be inoperable.

An energy efficient building is assumed to be a key component in each of these building scenarios.

3 HORIZONS OF TECHNICAL INNOVATION



3 HORIZONS OF INNOVATION FOR URBAN INFRASTRUCTURES

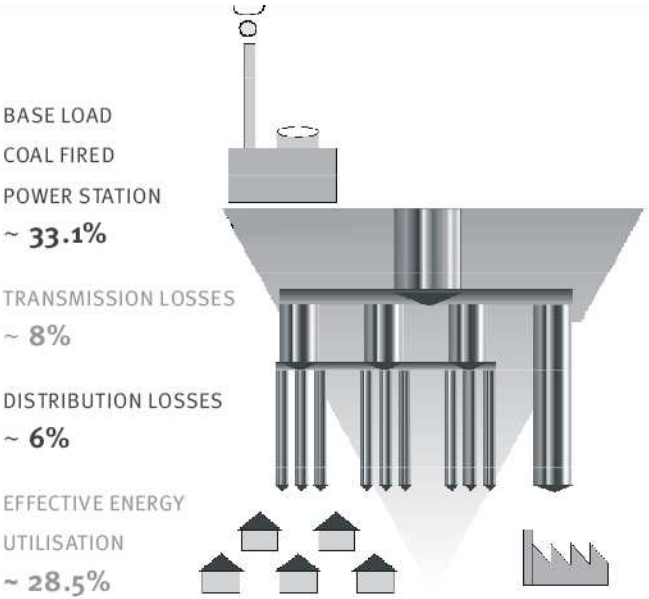
Urban Environmental Domain	H1	H2	H3
Energy	Energy efficiencies in housing and industry; house energy rating	Distributed renewable energy; methane bridge	Renewables-based solar-hydrogen economy
Water	Water-smart appliances	Sewer mining; water sensitive urban design	Integrated urban water systems (recycled stormwater, wastewater)
Buildings	Check box system for green building design (e.g. LEED)	nBL real-time life cycle sustainability performance assessment during design – via 3D CAD and GIS	Ultra-smart buildings and linked infrastructures; imbedded intelligence
Waste	Product stewardship ;kerbside recycling	Extensive cradle to cradle production – single enterprise	Eco-industrial clusters as new engines for mega-metro economies
Transport & Communications	Road pricing; telepresence via broadband communications	Hybrid vehicles; smart land use-transport planning ;high speed rail	Intelligent transport systems (ITS); integrated land use and transport

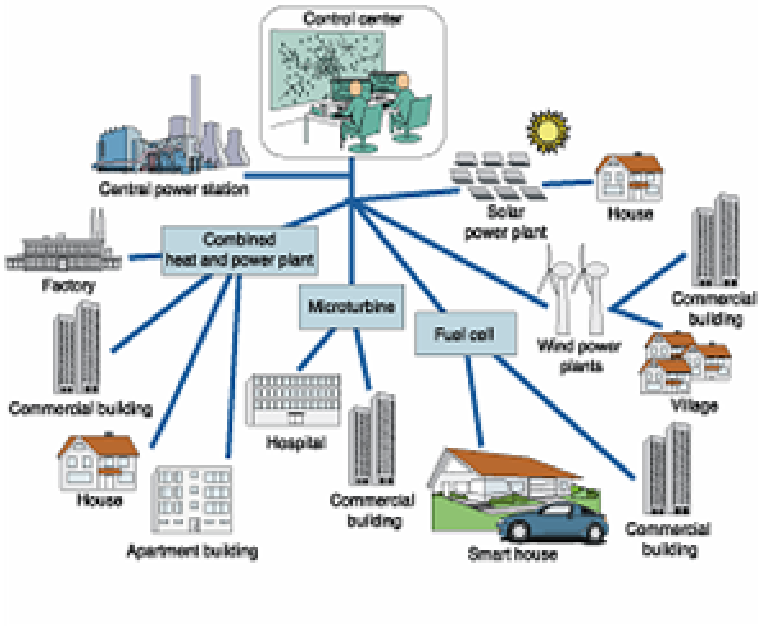
Source: *Newton*, (2007)

H2/H3 TRANSITION: DISTRIBUTED & RENEWABLE ENERGY

Transition to distributed generation in context of national grid

EXISTING CENTRALISED INDUSTRY	NEW DISTRIBUTED INDUSTRY



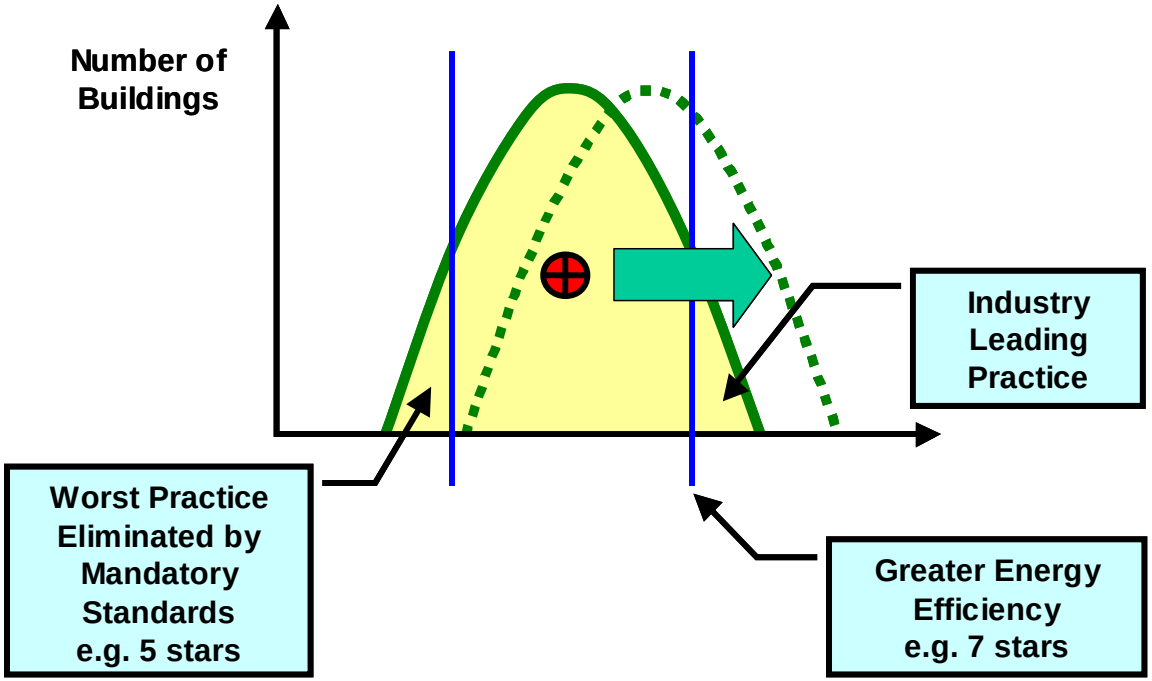


DOMESTIC ENERGY USE AND GREENHOUSE EMISSIONS: MELBOURNE 2007

2007	Electricity			Gas		Total	
	Energy		CO_2	Energy	CO_2	Energy	CO_2
LGA	Energy (kWh/ dwelling)	Energy (GJ /dwelling)	CO2 (kg/ dwelling)	Energy (GJ/ meter)	Energy CO_2 (kg/ meter)	Total (GJ/ dwelling)	Total (CO_2/ dwelling)
Glen Eira (C)	4639	17	6698	53	2754	70	9452
Greater Dandenong (C)	4919	18	7103	51	2616	68	9720
Wyndham (C)	5131	18	7409	50	2583	68	9992
Frankston (C)	5149	19	7435	50	2564	68	9999
Kingston (C)	5404	19	7803	50	2561	69	10363
Whitehorse (C)	5240	19	7567	58	3000	77	10567
Casey (C)	5386	19	7778	59	3072	79	10849
Latrobe (C)	5960	21	8606	48	2485	70	11092
Knox (C)	5565	20	8035	63	3236	83	11271
Monash (C)	5719	21	8258	60	3096	80	11354
Melbourne (C)	6543	24	9449	38	1970	62	11419
Boroondara (C)	6154	22	8886	62	3191	84	12078
Mornington Peninsula (S)	6841	25	9879	48	2504	73	12383
Bayside (C)	6530	24	9429	60	3121	84	12550
Manningham (C)	6218	22	8979	70	3602	92	12581
Stonnington (C)	7248	26	10466	51	2640	77	13106
Average	**5790**	**21**	**8361**	**54**	**2812**	**75**	**11173**
SD	**743**	**3**	**1074**	**8**	**399**	**8**	**1125**

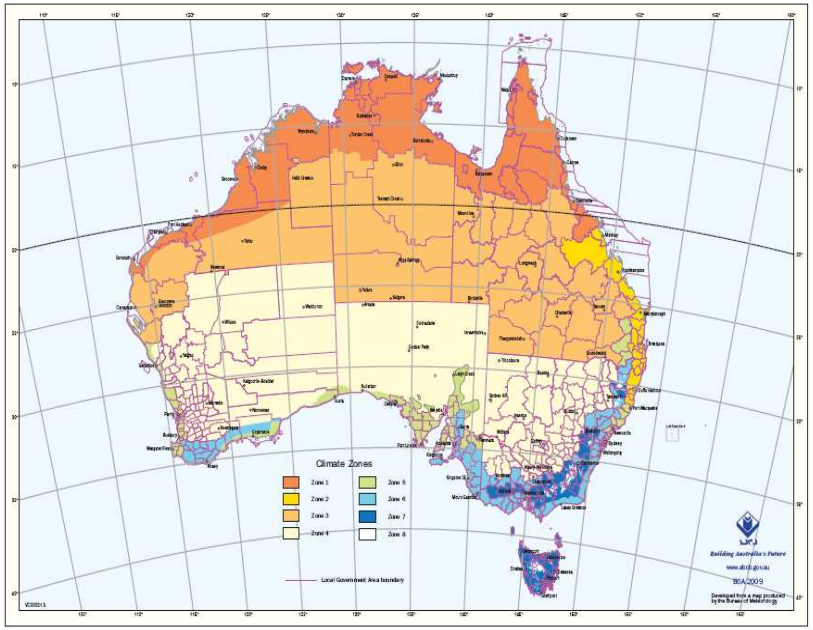
Sources: DSE (2008)

REGULATING CHANGE



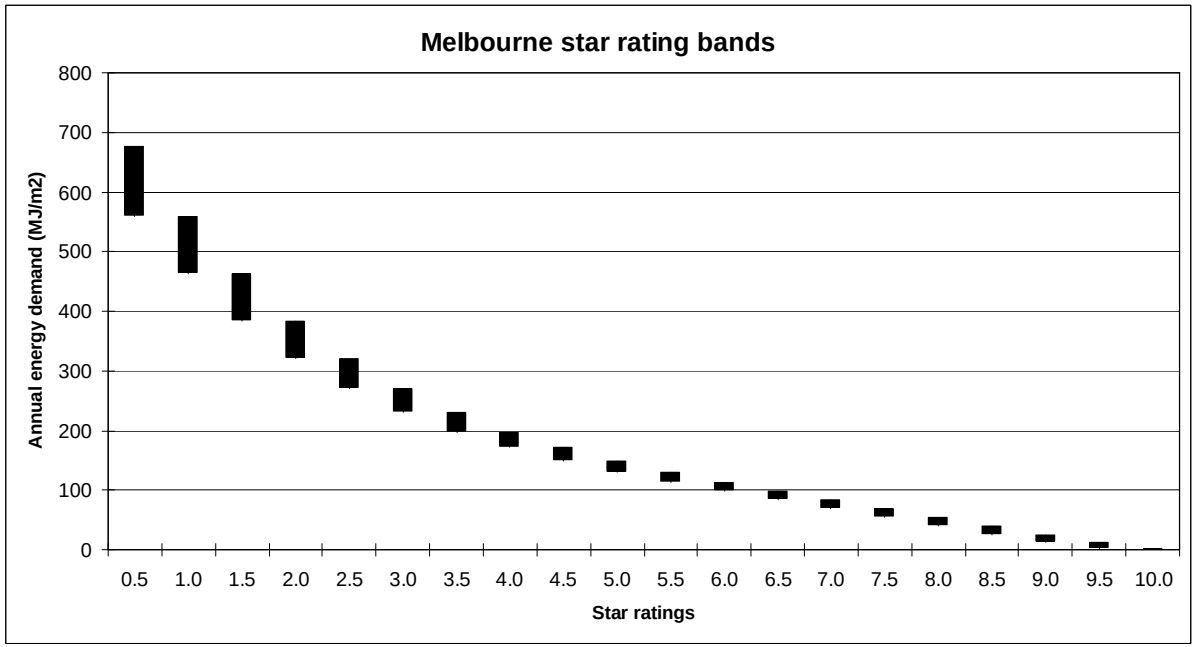
Sources: AGIC (2008)

CLIMATE ZONES OF AUSTRALIA



Climate zone	Description	Average 3 pm January water vapour pressure	Average January maximum temperature	Average July mean temperature	Average annual heating degree days
1	High humidity summer, warm winter	≥ 2.1 kPa	≥ 30ºC	-	-
2	Warm humid summer, mild winter	≥ 2.1 kPa	< 30ºC	-	-
3	Hot dry summer, warm winter	≤ 2.1 kPa	≥ 30ºC	≥ 14ºC	-
4	Hot dry summer, cool winter	≤ 2.1 kPa	≥ 30ºC	< 14ºC	-
5	Warm temperate	≤ 2.1 kPa	< 30ºC	-	< 1000
6	Mild temperate	≤ 2.1 kPa	< 30ºC	-	1000 to 1999
7	Cool temperate	≤ 2.1 kPa	< 30ºC	-	2000 to alpine
8	Areas defined as “alpine” in the BCA				

ENERGY EFFICIENCY: BUILDING SHELL

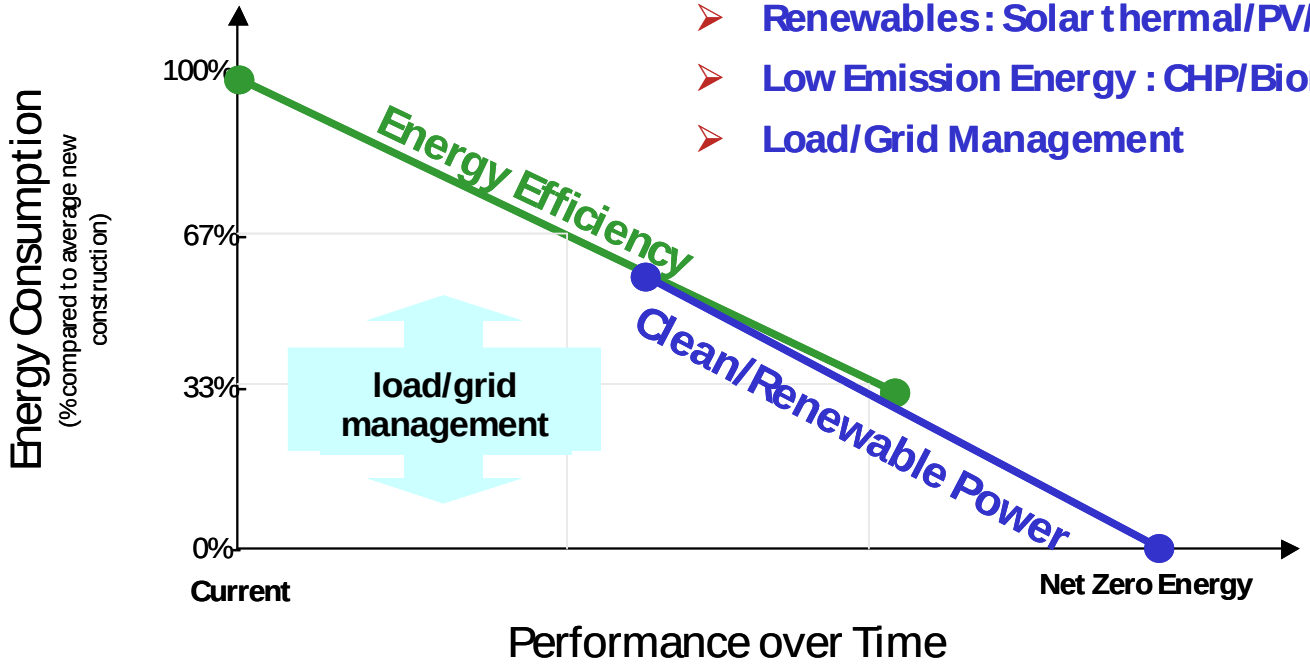


Sources: Delsante (2007) extract from Accurate energy rating software provided to authors

HYBRID BUILDINGS:
TRANSITIONING TO ZERO CARBON HOUSING

The Net Zero Approach:

- Integrated Solar Design
- Energy Efficiency—Shell+Appliances
- Renewables: Solar thermal/PV/Wind etc
- Low Emission Energy : CHP/Biomass etc
- Load/Grid Management



ARCHETYPAL DWELLINGS FOR HYBRID BUILDINGS

Detached Single Storey Housing

Sources: Tony Issacs Consulting (2007a)

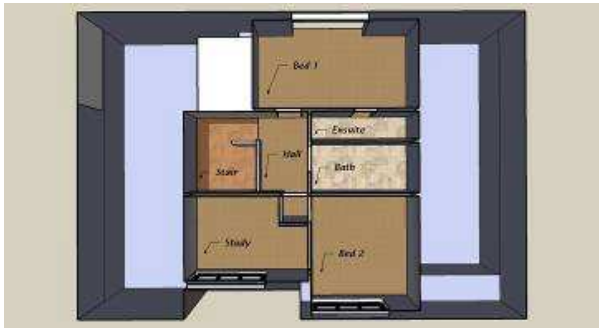
Detached Two Storey Housing

Sources: Tony Issacs Consulting (2007a)

ARCHETYPAL DWELLINGS FOR HYBRID BUILDINGS

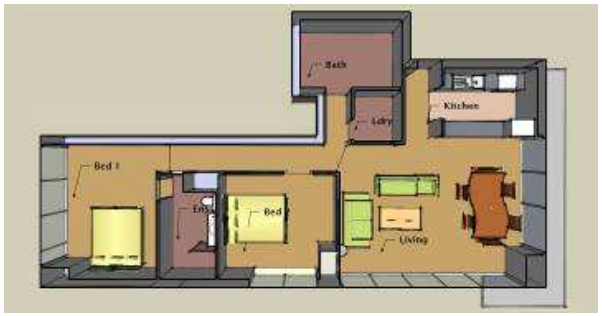
Medium Density Walk-up Flat (no lift)

Sources: Tony Issacs Consulting (2007a)

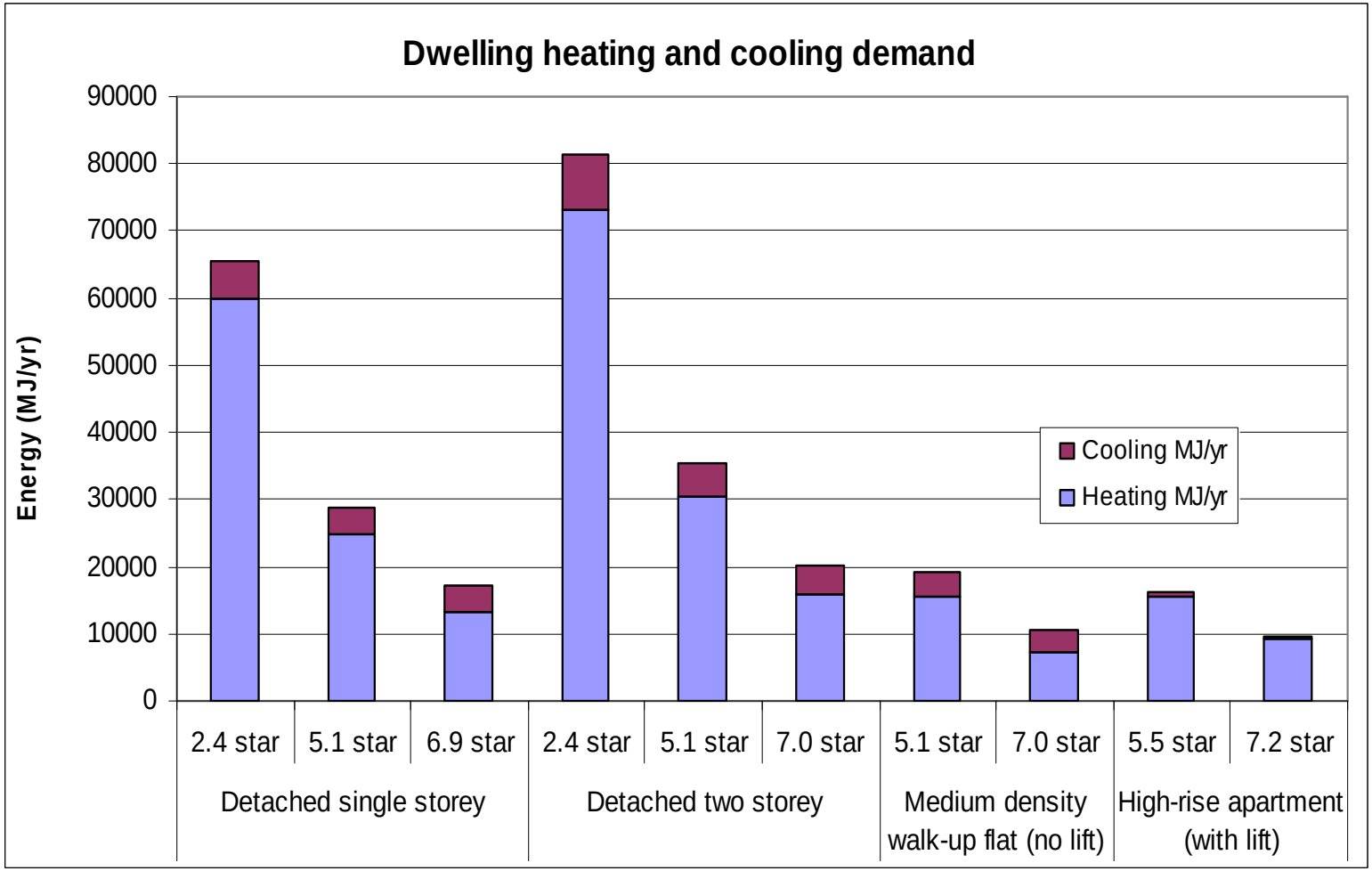


High-rise Apartment (with lift)

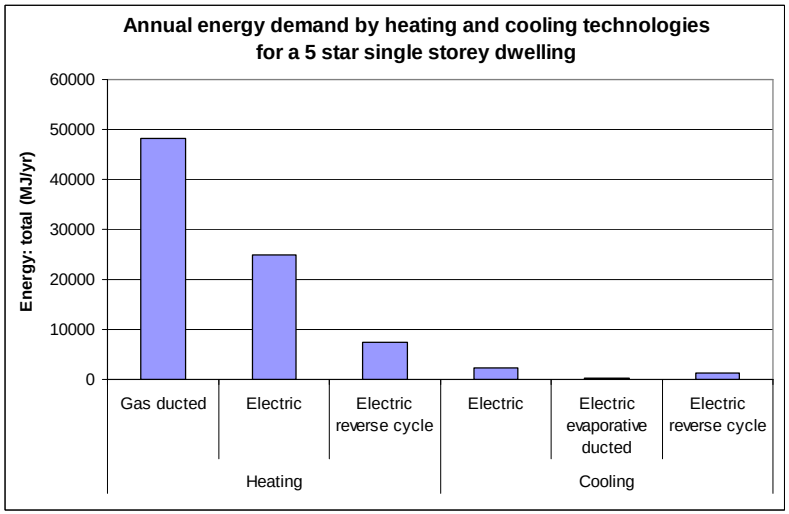
Sources: Tony Issacs Consulting (2007a)

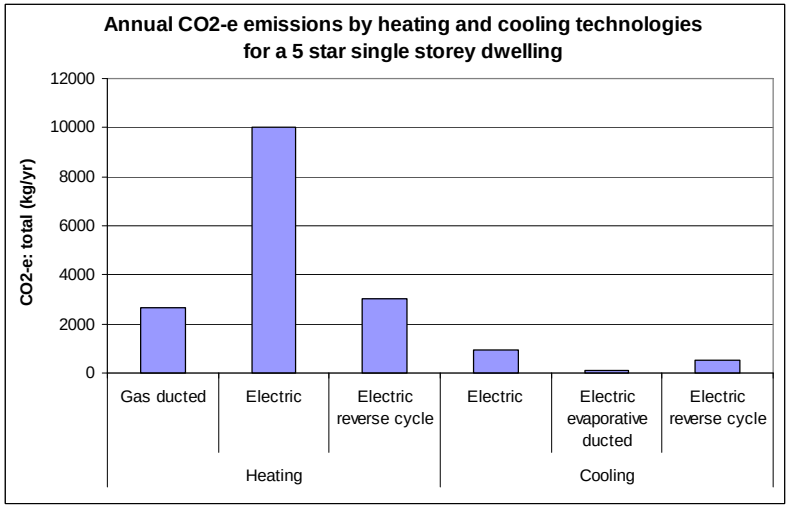


DWELLING HEATING AND COOLING DEMANDS



ENERGY AND GHG PROFILE FOR HEATING AND COOLING TECHNOLOGIES

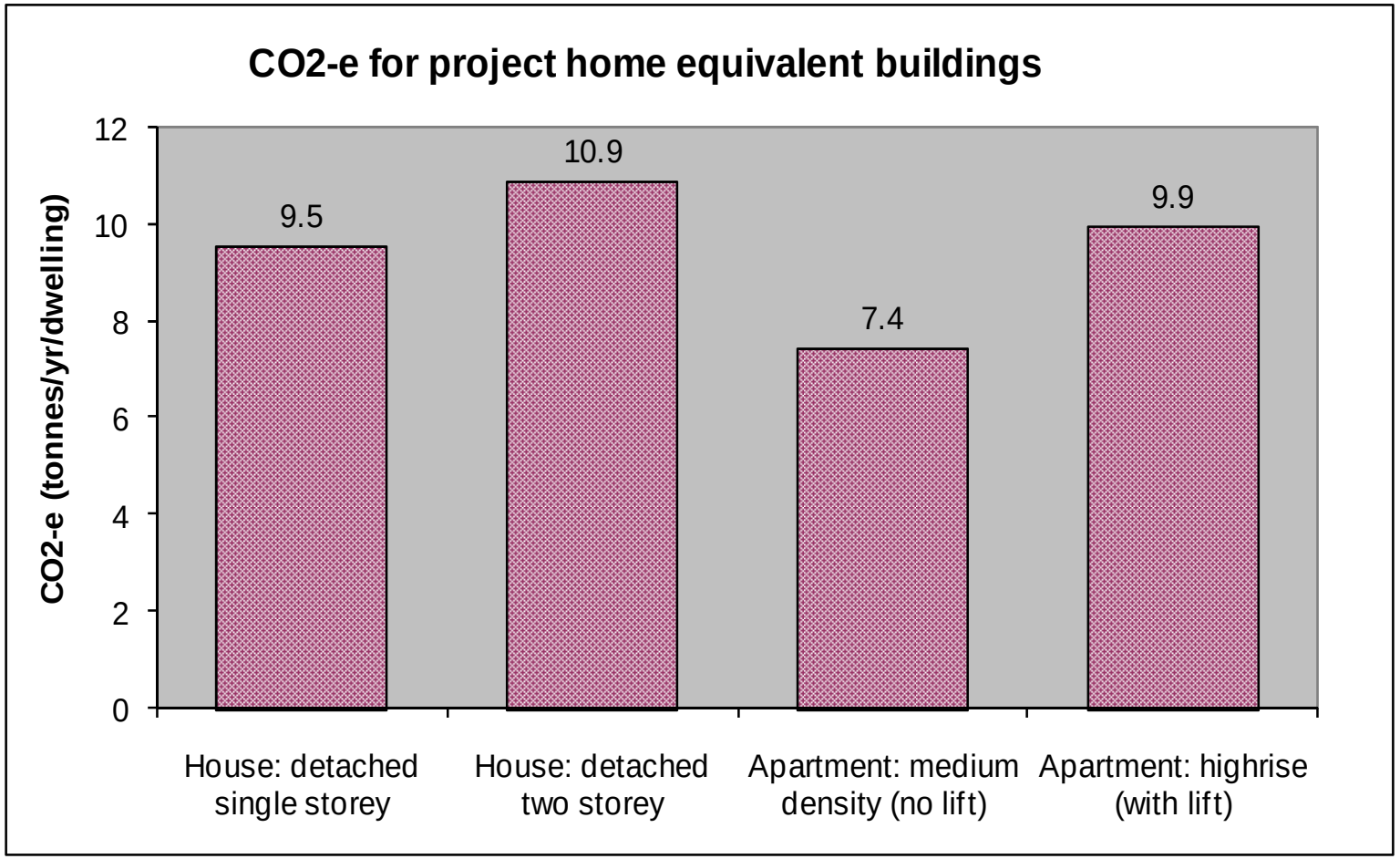




DOES DWELLING TYPE MATTER?

Selection	Case 1	Case 2	Case 3	Case 4
Dwelling type	Detached single storey	Detached two storey	Medium density	High-rise
Star rating	5 Star	5 star	5 Star	5 star
Space heating and cooling	Gas ducted and electric evaporative	Gas ducted and electric evaporative	Gas ducted and electric evaporative	Electric reverse cycle
Hot water	Gas – storage	Gas – storage	Gas – storage	Electric shared services
Cooking	Gas cooktop, electric oven, microwave	Gas cooktop, electric oven, microwave	Gas cooktop, electric oven, microwave	Electric cooktop, electric oven, microwave
Lighting	Average mix	Average mix	Average mix	Average mix
Appliances	'Best of breed' basic	'Best of breed' basic	'Best of breed' basic	'Best of breed' basic
Common services	None	None	Low rise	High-rise
Local generation 1	None	None	None	None
Local generation 2	None	None	None	None
Local generation 3	None	None	None	None
Energy used by consumption (MJ/yr)	84866	97619	56916	47700
Energy generated by local energy generation (MJ/yr)	0	0	0	0
Energy supplied by grid (MJ/yr)	84866	97619	56916	47700
CO2-e emitted by consumption (kg/yr)	9529	10868	7417	9915
CO2-e saved by local generation (kg/yr)	0	0	0	0
CO2-e net emitted by the grid supply (kg/yr)	9529	10868	7417	9915
Cost AEC ($/yr)	4958	5332	4266	4321

DOES DWELLING TYPE MATTER?

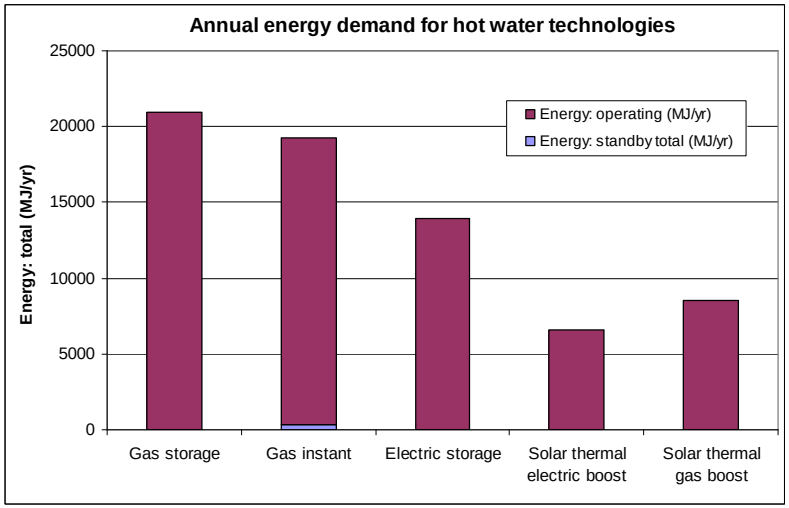


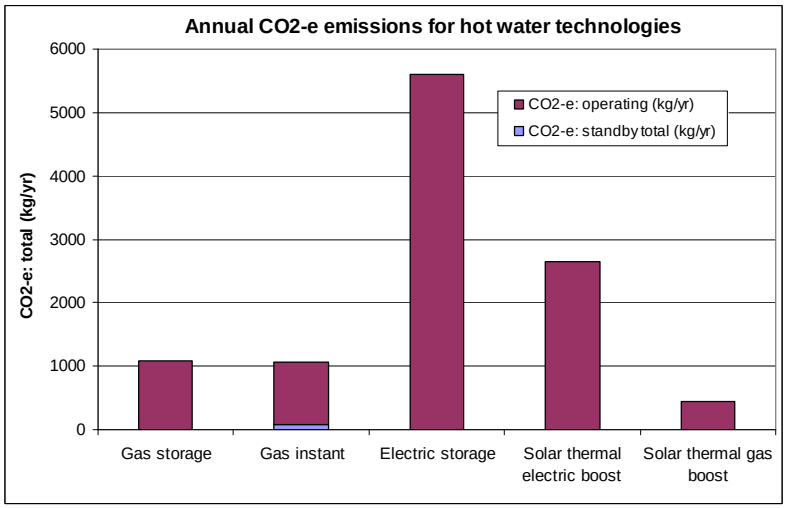
DOMESTIC APPLIANCES

Appliance
Hot water
Hot water - gas - storage
Hot water - gas - instant
Hot water - electric
Hot water - solar thermal
Hot water - shared services
Built-in appliances
Cooktop - gas
Cooktop - electric
Oven - electric
Oven - gas
Microwave oven
Lighting
Common area energy (Class2 buildings)

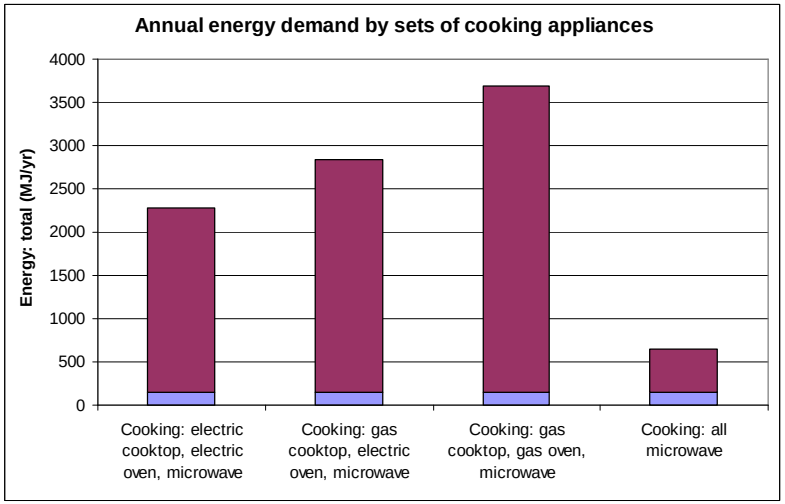
Plug-in appliances
Refrigerator/freezer
Dishwasher
Washing machine
Clothes dryer
Television
Computer
Home entertainment systems
Set top box
Kettle - electric

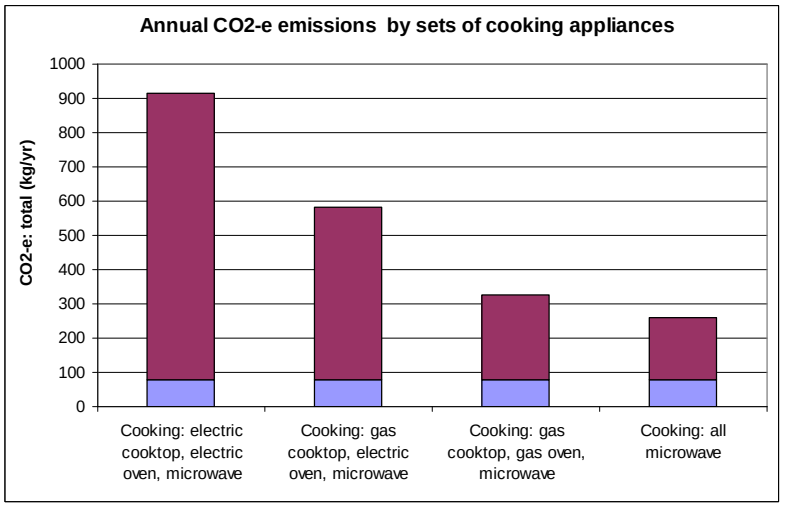
ENERGY AND GHG PROFILE FOR HOT WATER HEATING TECHNOLOGIES



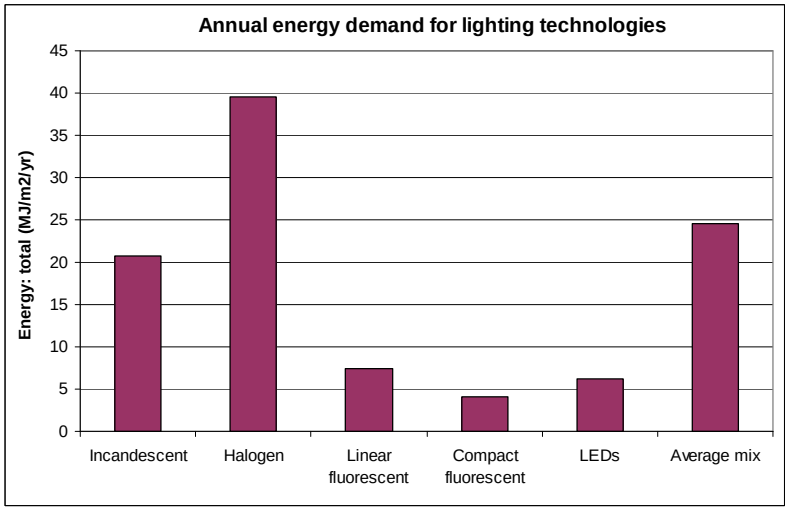


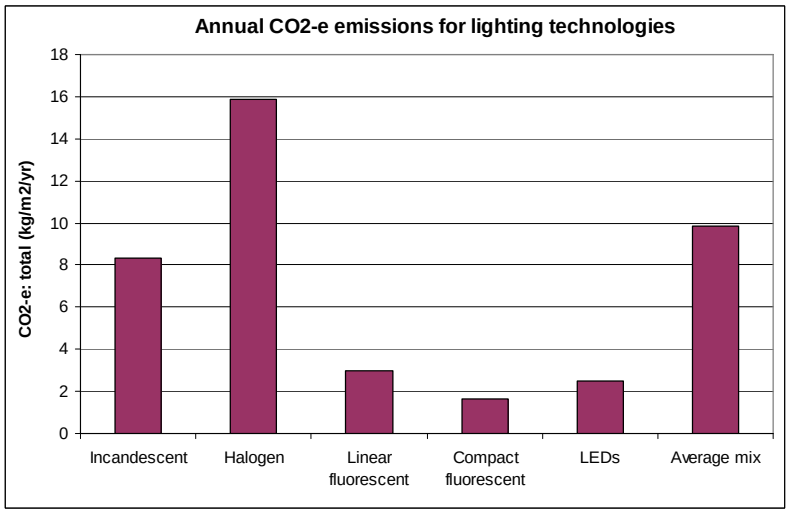
ENERGY AND GHG PROFILE FOR KITCHEN SCENARIOS



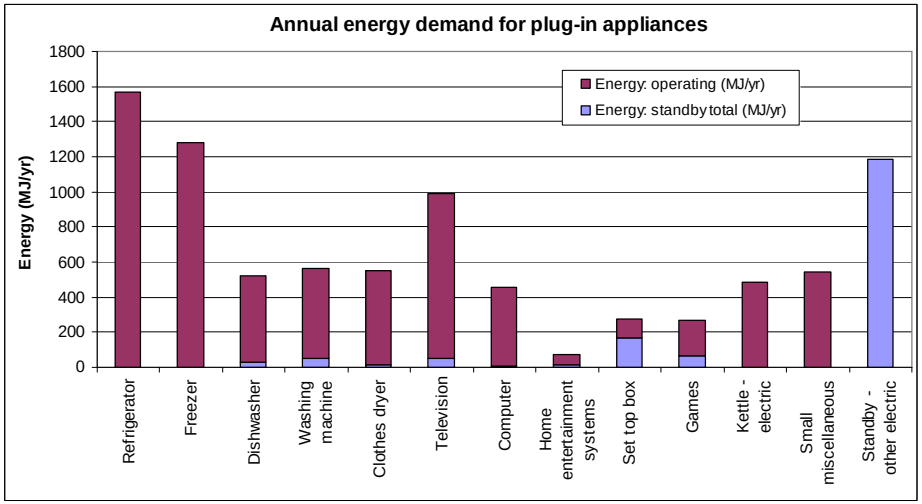


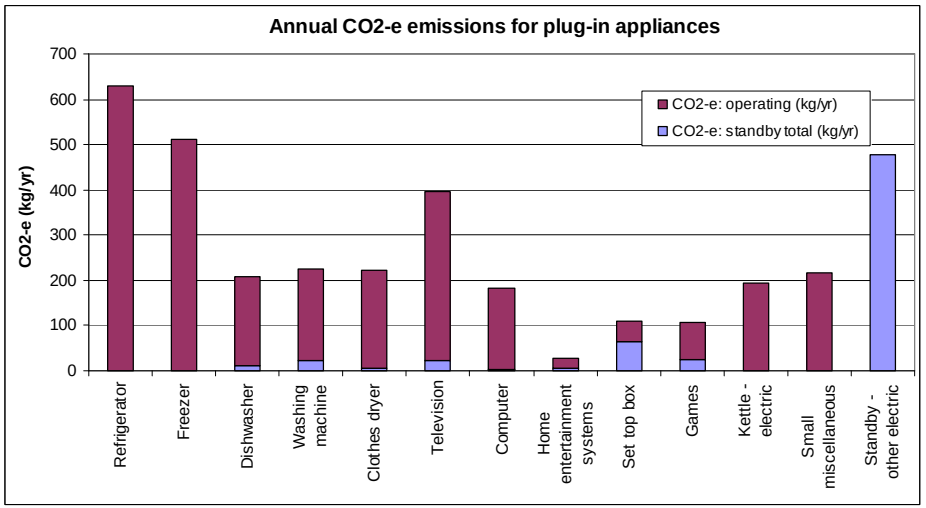
ENERGY AND GHG PROFILE FOR LIGHTING SCENARIOS



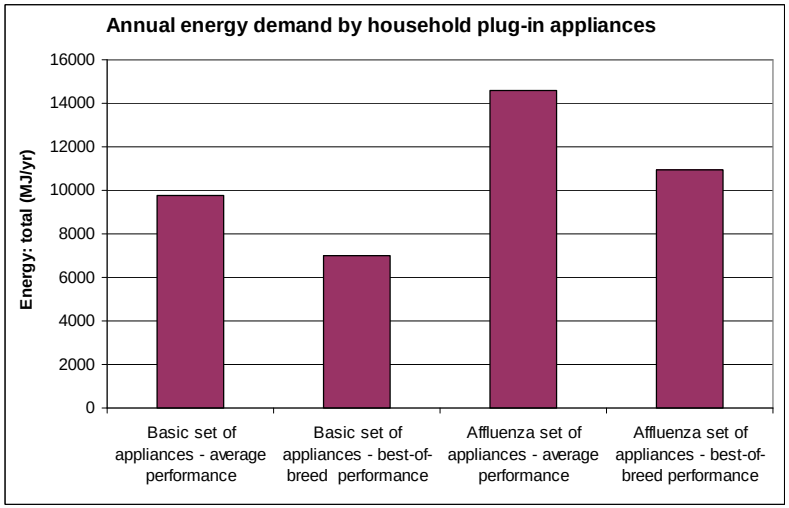


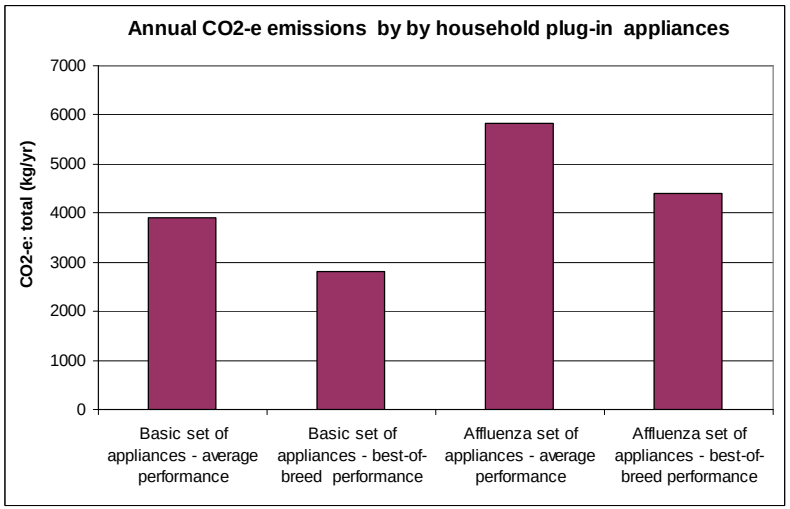
ENERGY AND GHG PROFILE FOR PLUG-IN APPLIANCES



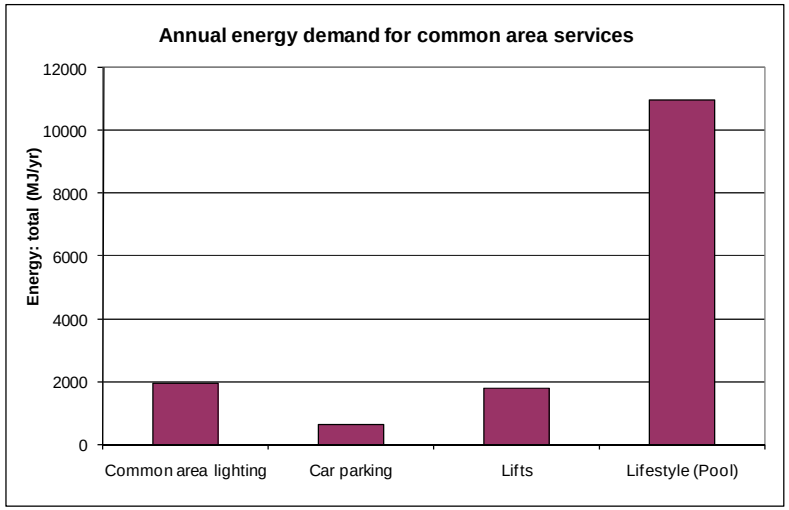


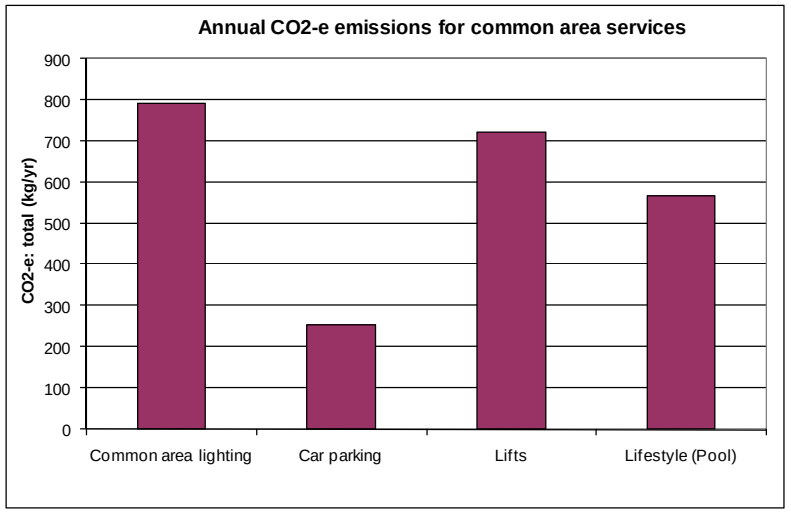
ENERGY AND GHG PROFILE
FOR BASIC VS. AFFLUENZA APPLIANCE SCNEARIOS





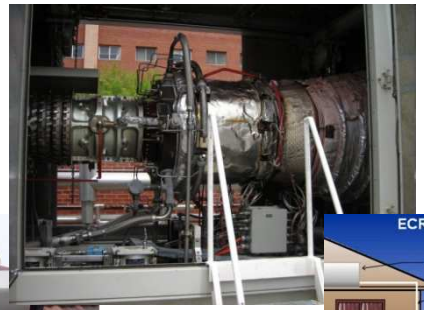
ENERGY AND GHG PROFILE FOR COMMON AREA SERVICES IN HIGH-RISE APARTMENTS (PER APARTMENT)

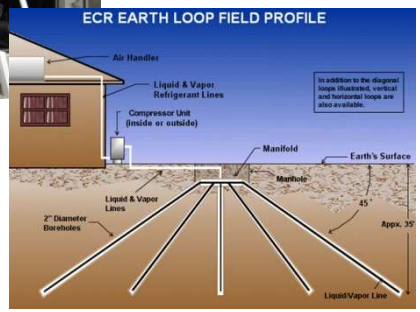




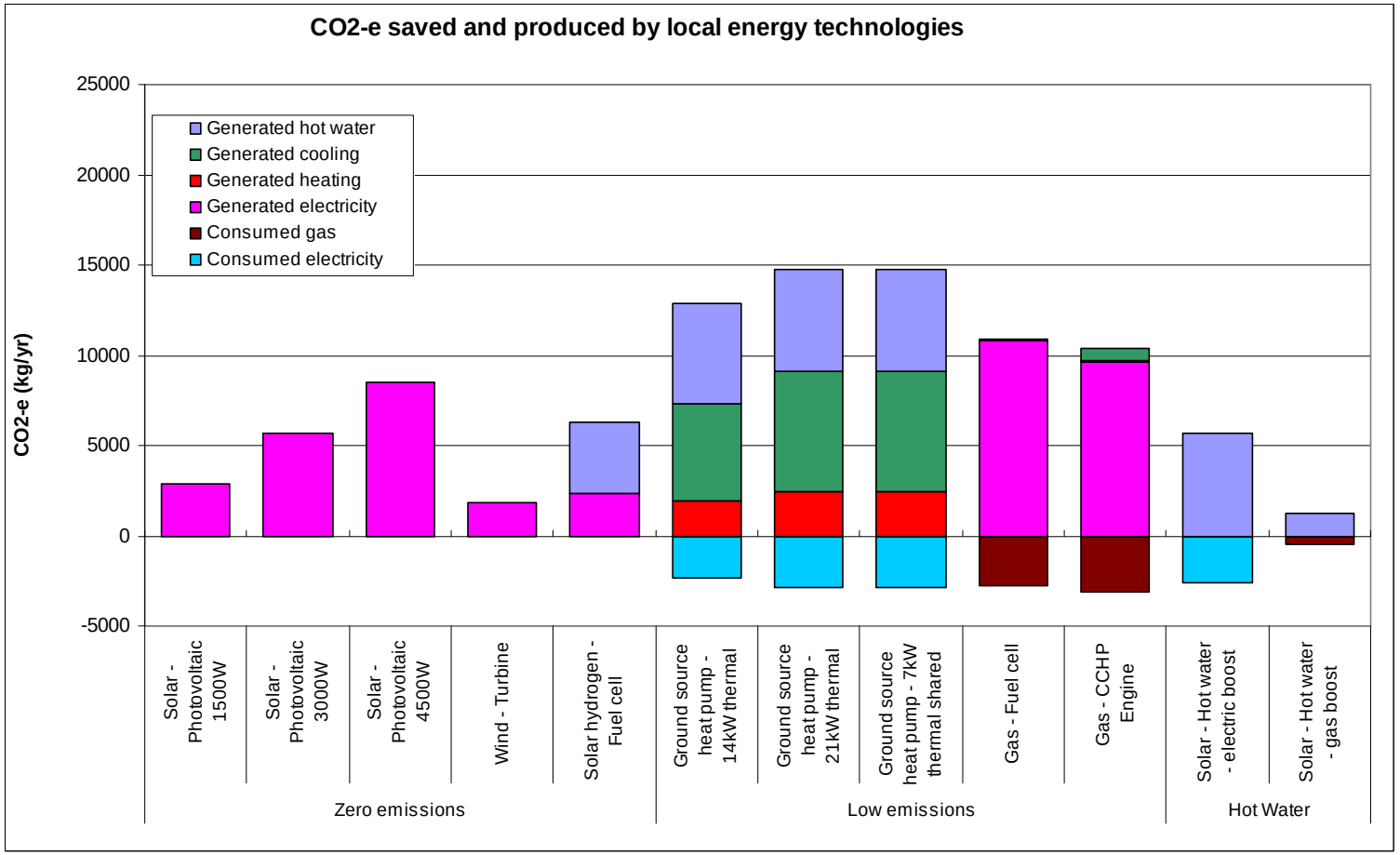
LOCAL ENERGY GENERATION TECHNOLOGIES

- Photovoltaics (PV)
- Solar gas boosted thermal
- Wind
- Fuel Cell (gas, solar)
- Gas CCHP (combined cooling, heat and power)
- Ground source heat pump





ENERGY AND GHG PROFILE FOR ALTERNATIVE LOCAL ENERGY GENERATION TECHNOLOGIES



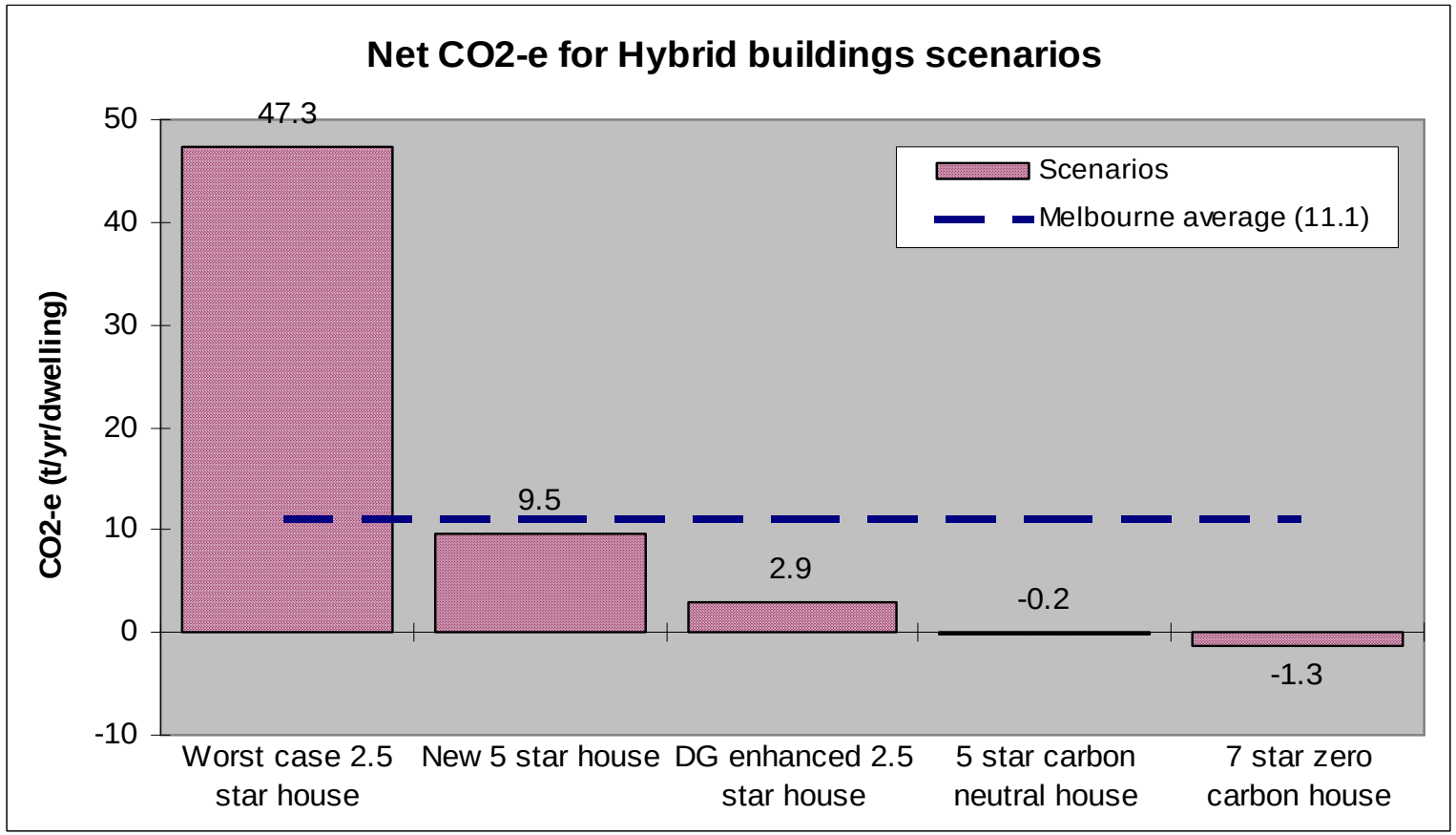
SCENARIO MODELLING:
MULTIPLE HYBRID BUILDING SCENARIOS

Scenario A	Test case 1
Dwelling type	House: detached single storey
Star rating	5 star
Space heating and cooling	Heating/cooling: gas ducted and electric evaporative
Hot water	Hot water: gas - storage
Cooking appliances	Cooking: gas cooktop, electric oven, microwave
Lighting	Lighting – all compact fluorescent
Appliances	Appliances: project homes
Common area services	Common services: none
Local generation	Solar - Photovoltaic

SCENARIOS FOR ASSESSING TRANSITION TO ZERO CARBON DWELLINGS

Selection	Case 1	Case 2	Case 3	Case 4	Case 5
Dwelling type	Detached single storey	Detached single storey	Detached single storey	Detached single storey	Detached single storey
Star rating	2.5 Star	5 star	2.5 Star	5 star	7 Star
Space heating and cooling	Electric heating and cooling	Gas ducted and electric evaporative	Gas ducted and electric evaporative	Gas ducted and electric evaporative replaced by GSHP	Electric reverse cycle replaced by GSHP
Hot water	Electric	Gas – storage	Solar thermal – gas boost	Solar thermal – gas boost replaced by GSHP	Solar thermal – gas boost replaced by GSHP
Cooking	Electric cooktop, electric oven, microwave	Gas cooktop, electric oven, microwave	Gas cooktop, gas oven, microwave	Gas cooktop, gas oven, microwave	All microwave
Lighting	All halogen	Average mix	All compact fluorescent	All compact fluorescent	All compact fluorescent
Appliances	Average performance affluenza	'Best of breed' basic	'Best of breed' basic	'Best of breed' basic	'Best of breed' basic
Local generation 1	None	None	Solar – Photovoltaic 4500 W	Ground source heat pump – 14kW thermal	Ground source heat pump – 14kW thermal
Local generation 2	None	None	None	Solar – Photovoltaic 1500 W	Solar – Photovoltaic 3000 W
Local generation 3	None	None	None	Wind turbine	None
Energy used by consumption (MJ/yr)	117894	84866	151117	83262	37177
Energy generated by local energy generation (MJ/yr)	0	0	33726	80954	40515
Energy supplied by grid (MJ/yr)	117894	84866	117391	2307	-3338
CO2-e emitted by consumption (kg/yr)	47289	9529	12096	8291	7584
CO2-e saved by local generation (kg/yr)	0	0	9181	8519	8923
CO2-e net emitted by the grid supply (kg/yr)	47289	9529	2915	-227	-1339
Cost AEC ($/yr)	12771	4958	8363	5994	5551
NZE target	×	×	×	×	✓
CN target	×	×	×	✓	✓
ZC target	×	×	×	×	✓

NET CO_2-e EMISSIONS FOR SELECTED SCENARIOS IN TRANSITION TO ZERO CARBON DWELLINGS



HYBRID BUILDING AND TECHNOLOGY-BASED INNOVATION

Building Shell

- 2.5 to 5.0 Star =56% reduction in annual energy use for heating and cooling
- 5.0 to 7.0 Star =18% reduction in annual energy use
- 2.5 to 7.0 star =74% reduction in annual energy use (equivalent to saving of 48,300 MJ/yr per detached dwelling)

HYBRID BUILDING AND TECHNOLOGY-BASED INNOVATION

Appliances

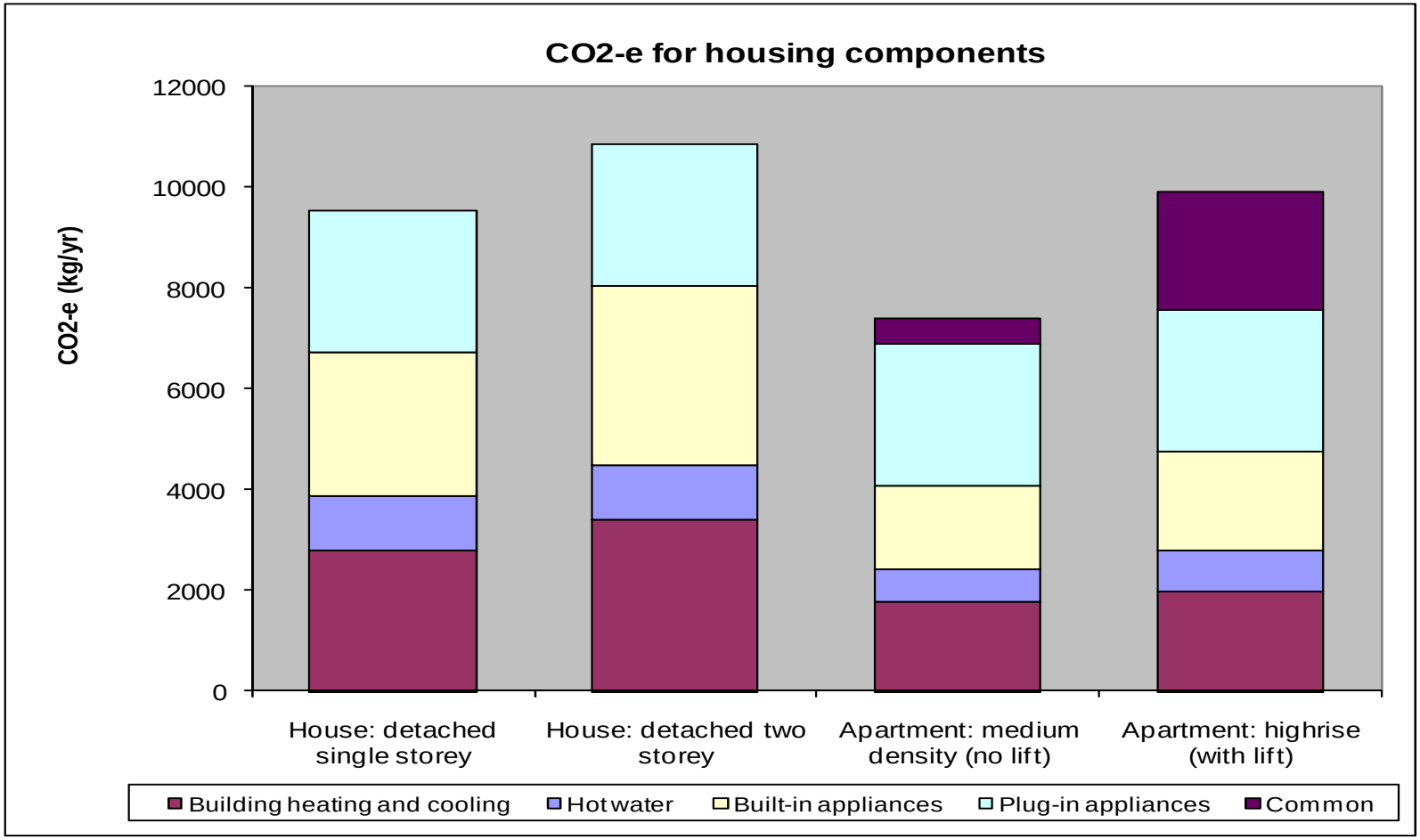
- 92% reduction in annual CO_2 from hot water heating with substitution of solar thermal gas boosted for electric storage
- 28% reduction in annual CO_2 from plug-in appliances with substitution of ‘best-of-breed’ for average energy efficiency
- 72% reduction in annual CO_2 with shift from all electric (cooktop+oven) to all microwave
- 89% reduction in annual CO_2 with shift from all halogen to all compact fluorescents

Hybrid Buildings

- Annual net savings of GHG per dwelling in shifting from a 5-star grid connected project home to a 5-star zero carbon home is of the order of 11 tonnes CO_2

FUTURE AREAS FOR REGULATION?

BUILT-IN EQUIPMENT/APPLIANCES?



SWINBURNE UNIVERSITY OF TECHNOLOGY

THANK YOU

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