What is the case for electricity efficiency initiatives?

Concept Consulting Group Ltd

Summary of findings

- Electricity efficiency (EE) matters
  - Electricity is costly to produce & transport
  - Cost of provision particularly high in peak demand periods
- Potential economic benefits from EE (only residential sector considered)
  - Estimated at $300 million in net terms over 10 years
  - Equates to 6% of estimated technical potential
- Why won't these benefits be realised without action?
  - Externalities: mis-pricing of power and carbon
  - Consumer inertia/confusion, principal-agent issues & transaction costs
- Estimates exclude potential additional benefits in non-carbon environmental and social areas – not possible to quantify these within scope of our engagement

Summary of findings (cont'd)

- Other unquantified potential benefits
  - Commercial/industrial user demand excluded from estimates
  - Switching process heat from fossil fuel to electricity (new tech)

- Issues for EECA to consider
  - Appears that significant efficiency benefits remain to be captured
  - Key challenge likely to be proving the realisability of program actions
  - Recent changes to allow customers to obtain their TOU meter data provide increased scope for targeting and measuring benefits

Setting the scene

Purpose and context

Context

- The electricity sector is experiencing significant change:
  - High levels of renewable electricity generation >80%
  - New technologies emerging – such as electric vehicles, solar panels and household batteries
  - Increasing focus on improving price signals for consumers

Purpose

- Against this background, this report examines the case for EECA to pursue electricity efficiency initiatives
- In particular, we look at:
  - Are there any electricity efficiency benefits left to chase?
  - Where are the main benefits?
  - Where should EECA focus its effort?

Terminology – what do we mean by ‘electricity efficiency’

- Actions that produce more benefit for NZ, per unit of input, in electricity sector context
- Improved ‘end use’ electric technologies – e.g.
  - LED replacing CFL/incandescent
  - more efficient refrigerators and other appliances
  - heat pumps replacing resistive heating
  - improved insulation
- Behavioural changes
  - timers on appliances (to reduce kWh/yr, and/or peak usage)
  - controlled electric water heating (so it’s off peak)
- Other
  - EVs charged overnight - improving network utilisation, and potentially grid support (via V2G)
  - fuel switching to wood/gas for space and/or water-heating and cooking

Decision framework – three key questions

1. Are there unrealised EE benefits for NZ?

What benefit (if any) is NZ not capturing at present? (put side whether both 'public' and 'private' at this stage)

↓

2. What action (if any) should government take?

Why are problems occurring – is it due to externalities, information problems, principal/agent issues, behavioural issues etc?

Do the benefits exceed the costs of intervention?

↓

3. Is EECA the best agency to manage the proposed action?

What skills, expertise and resources are needed to manage the proposed action? Affects whether EECA is in lead or support role?

Statutory framework indicates EECA should consider all benefits

EECA's functions

- "Encourage, promote, and support energy efficiency, energy conservation, and the use of renewable sources of energy" - s.20 Energy Efficiency and Conservation Act 2000
- The Act defines "energy efficiency as "a change to energy use that results in an *increase in net benefits per unit of energy*" (emphasis added)

Key observations

- "Efficiency" defined in a broad way – can be:
  - Reduced energy input for same level of useful energy service – or
  - No change in energy input for increased level of useful energy service
- Benefits also defined in broad way – EECA is required to consider all types of benefit - economic, environmental and social

Economic benefits

Direct economic benefits

Indirect economic benefits

Electricity efficiency

Reduced expenditure on networks

Reduced expenditure on generation

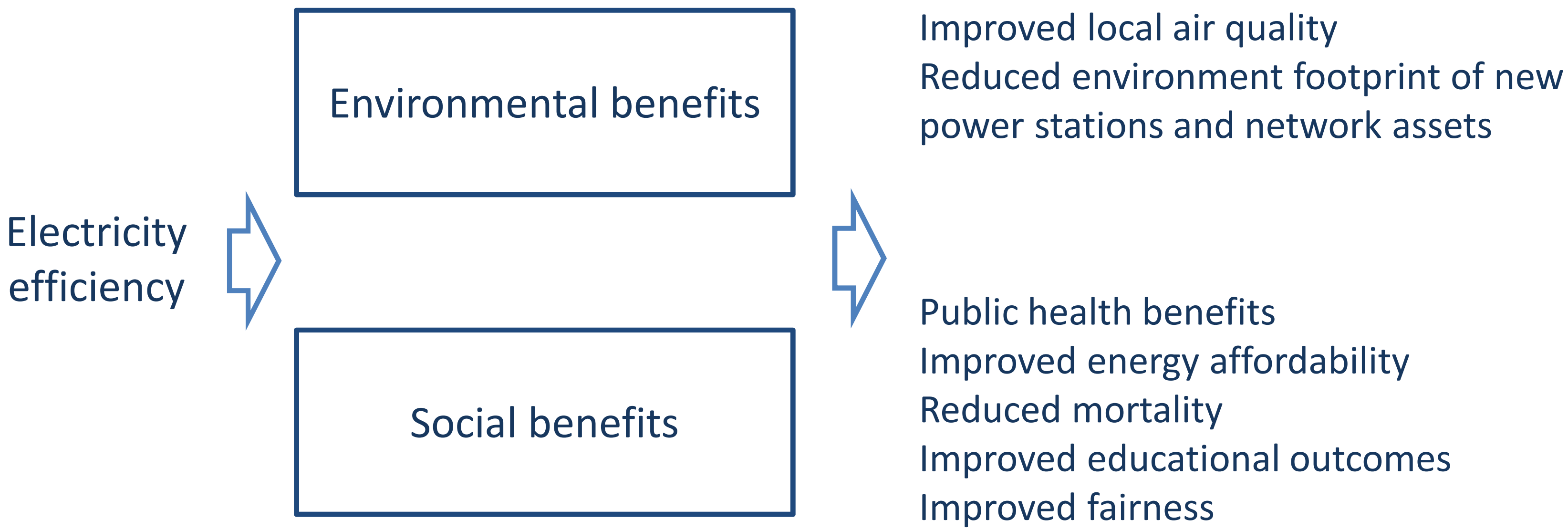
Reduced carbon costs

Higher productivity and competitiveness
Facilitates reduced transport emissions
Facilitates reduced process heat emissions
Greater electricity sector resilience
Greater employment growth
Higher GDP
Improved balance of payments
More informed consumer choices
Improved power system efficiency
Reputational benefits for NZ

Direct and indirect effects generally not additive – estimating benefits based on direct impacts is likely to be most reliable approach – be careful to not double count

Environmental and social benefits

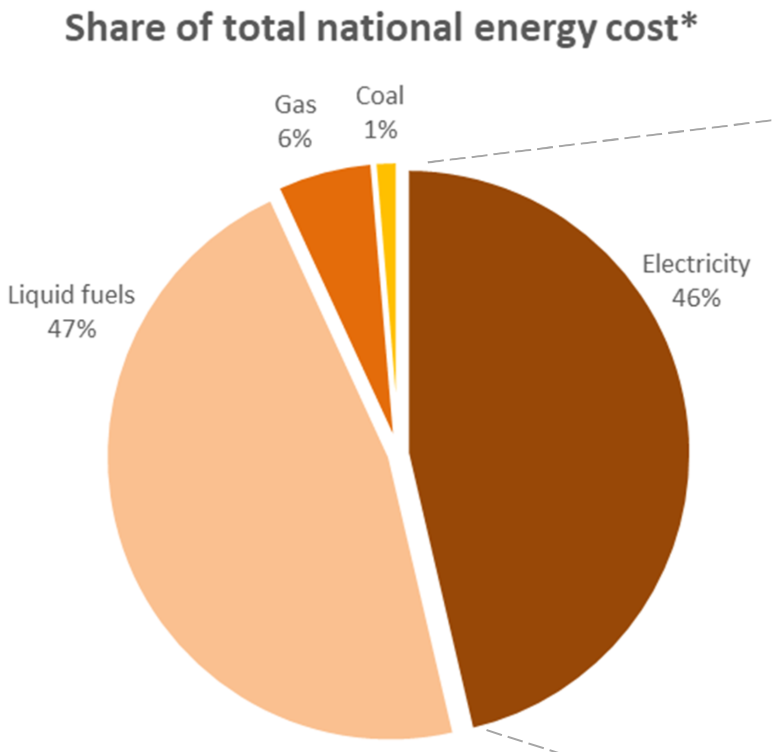
concept



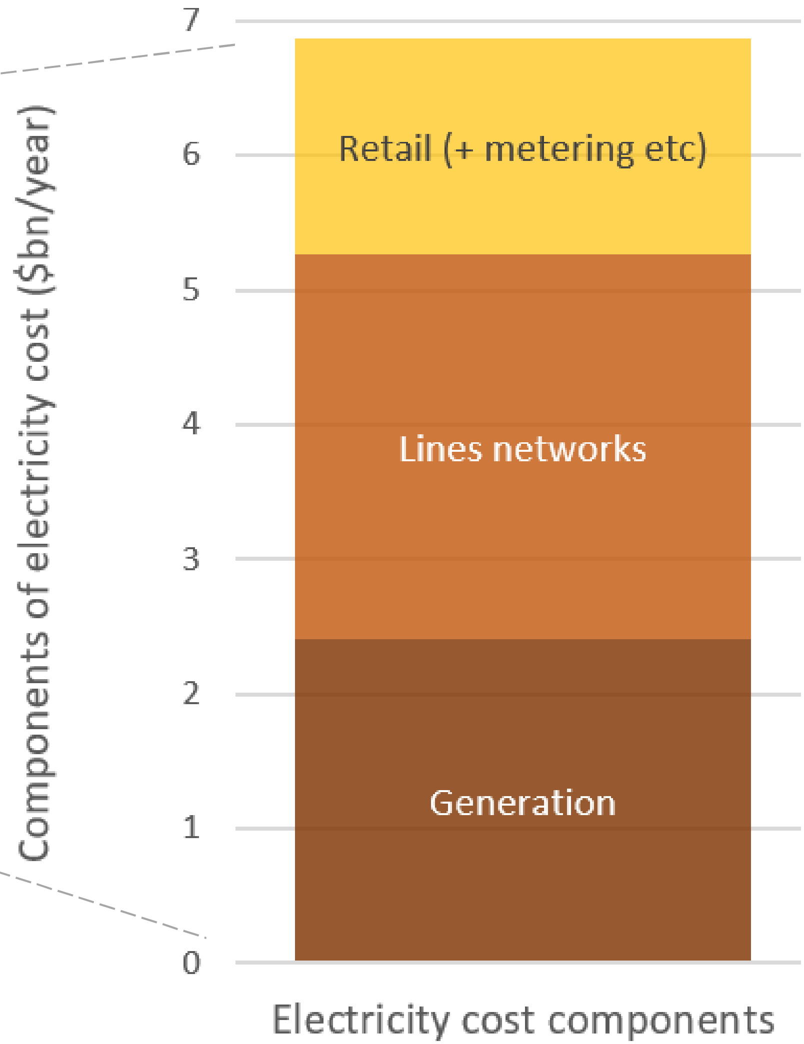
Typically more difficult to estimate value of environmental and social benefits as less data available – would be additional to economic benefits on previous slide

How big are the potential economic benefits?

Saving electricity remains valuable to NZ

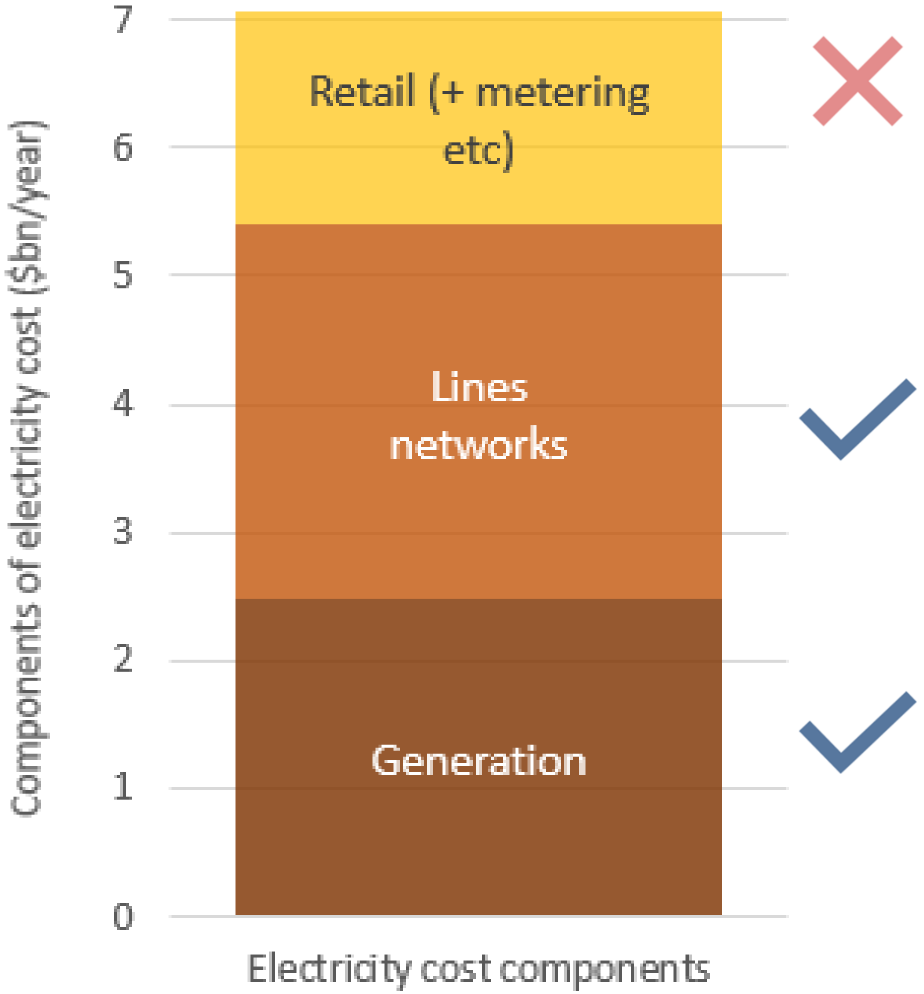


* . Excludes direct use renewables such as wood waste as no cost data available. To ensure comparability, costs exclude GST amd excise taxes



- Electricity is a high cost energy source
- NZ spent about $7bn on electricity in 2015
- Annual electricity cost comparable with NZ's liquid fuel bill

Reducing electricity usage can cut system costs



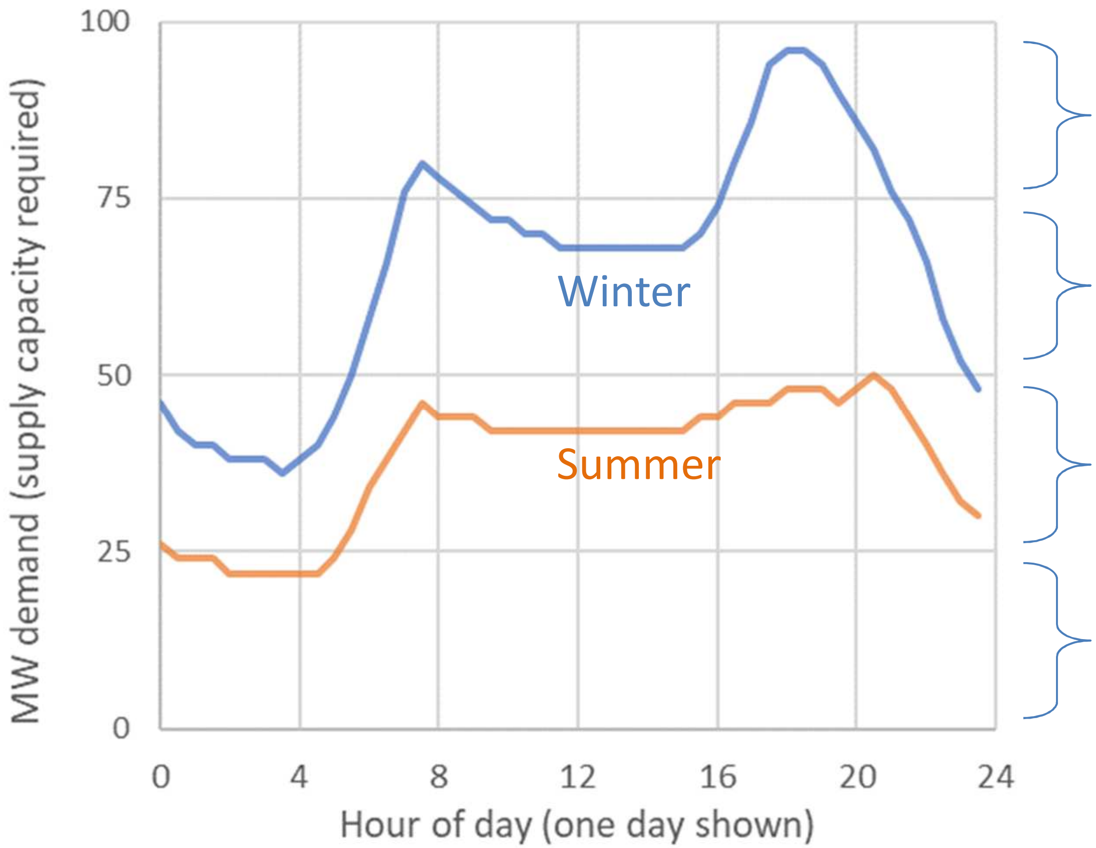
Not easily 'avoidable' through electricity efficiency alone

Around 50% of network costs are driven by peak capacity requirement – reducing peak usage allows cost savings

Generation costs are mostly 'avoidable' – peak and 'anytime' efficiency will have differing effects

Electricity savings at peak times are especially valuable

Imagine a hypothetical suburb with the demand profile below, supplied by four lines, each with a capacity of a quarter of the suburb's peak demand. The cost of each line is the same in $ amounts, but in c/kWh terms the last line that is used to meet winter peak is much more expensive than the first line that's always utilised (i.e. because the same cost is spread across far fewer kilowatt-hours).



This last 25% of capacity only has about 10% utilisation)

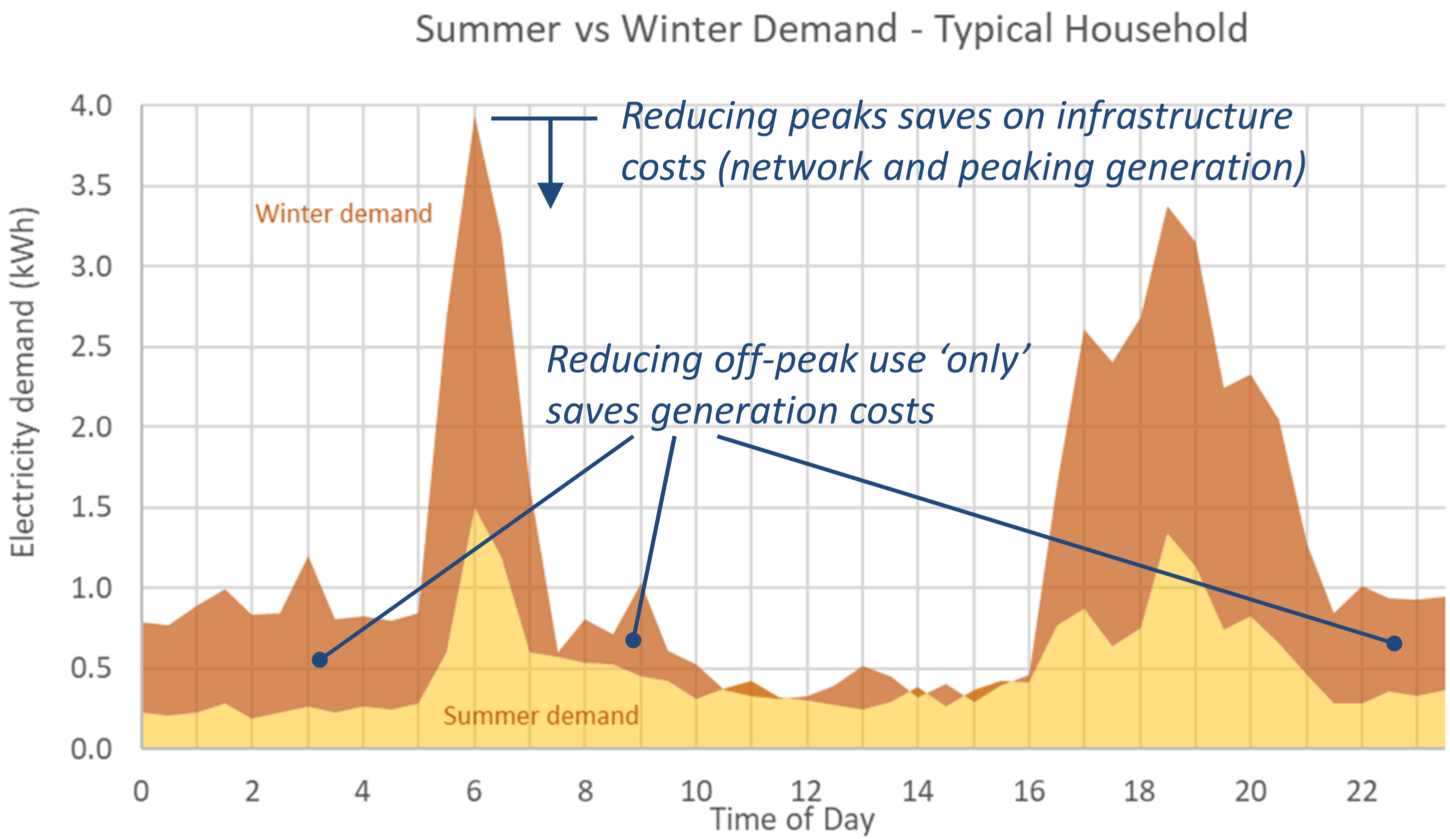
The next 25% of capacity is used less than half the time(~35% utilisation)

The next 25% of capacity is often in use (~80% asset utilisation)

The first 25% of capacity provided is almost always fully used (~100% utilisation)

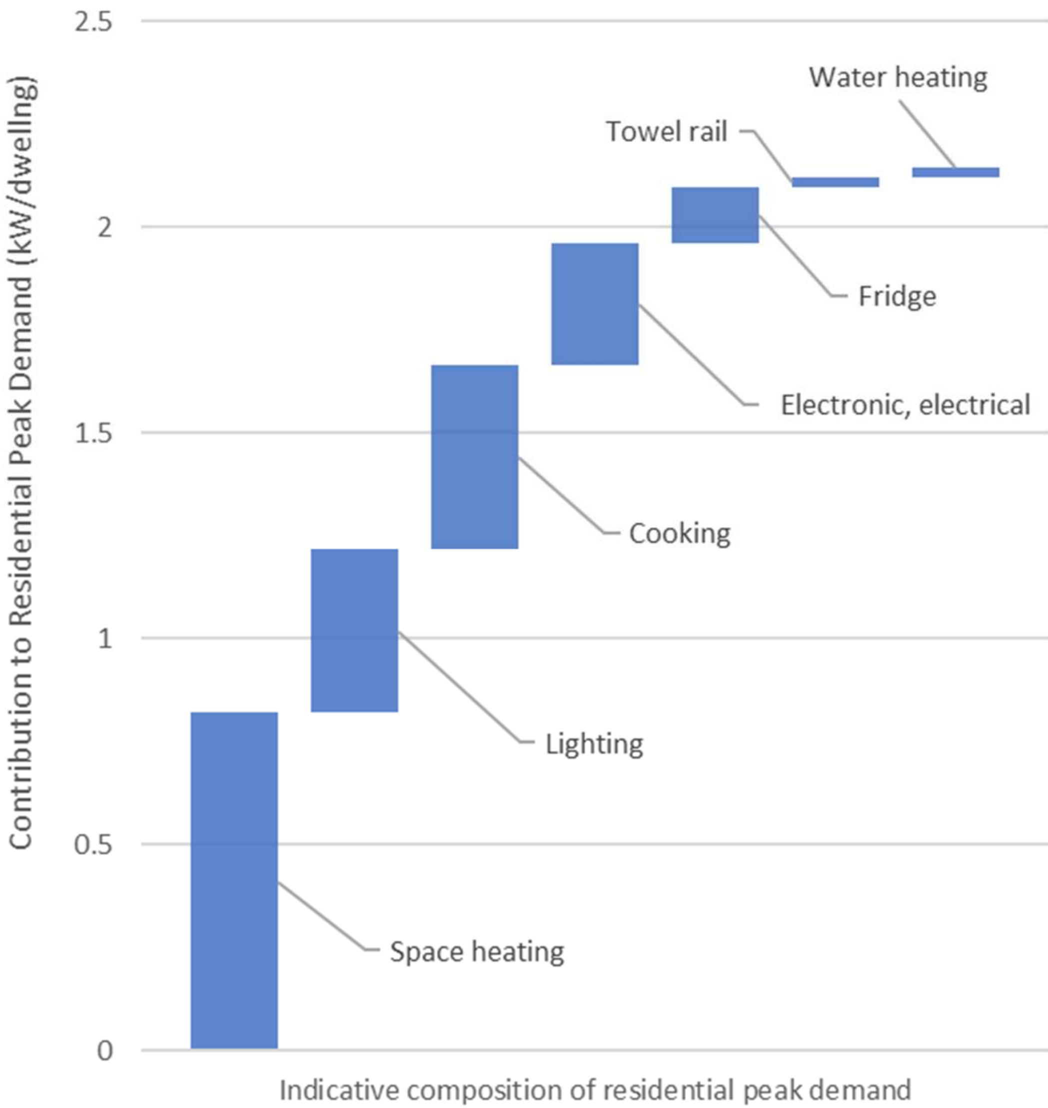
EECA should consider how benefits affected by time of saving

- Cost of providing electricity varies with time, i.e.
  - much more expensive to provide in winter/evening peaks
  - relatively cheaper at other times
- Value of EE depends on <u>when</u> electricity demand is reduced



Estimated make-up of household peak electricity demand

- Average peak demand is about 2.2kW/house
- More than half is due to lighting and space heating
- Every house is different, so an intervention can target specific households (e.g. by floor area as a proxy for heating/lighting load)



Lighting efficiency – system benefit (indicative)

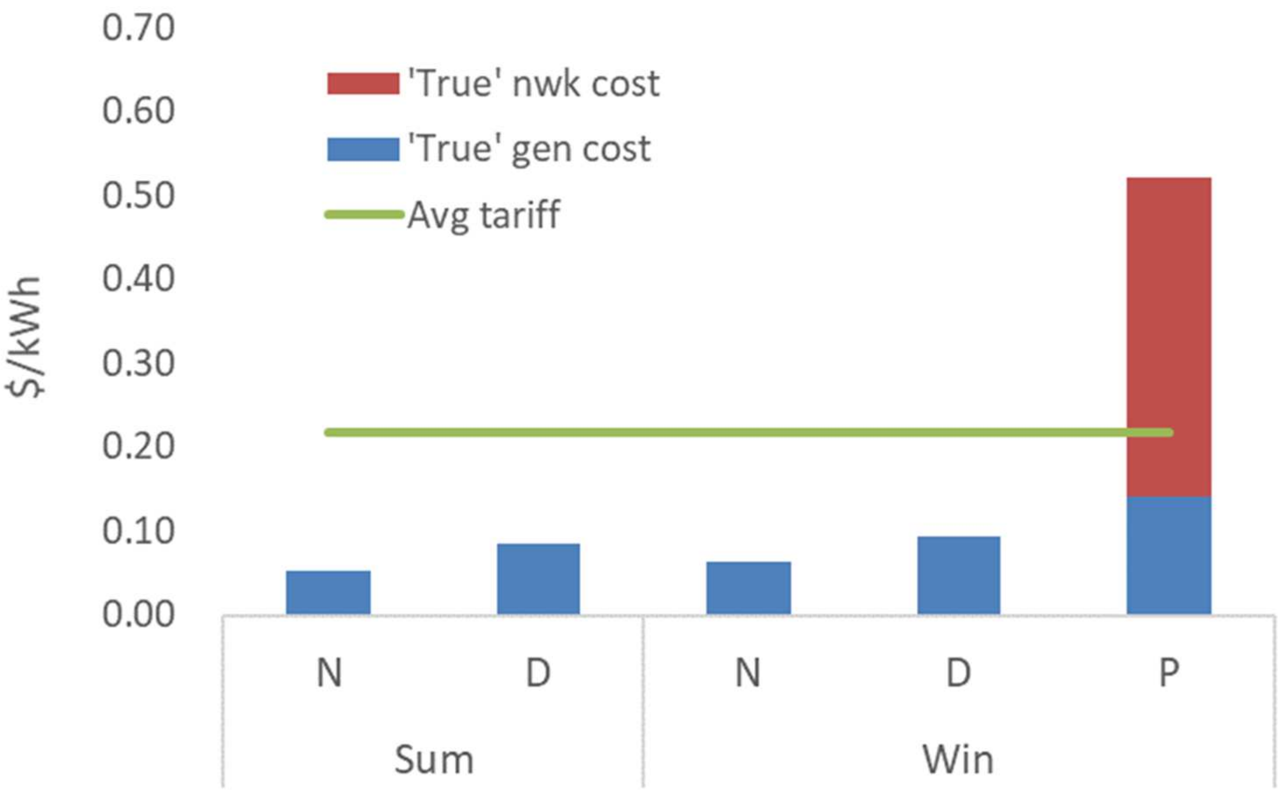
- A typical house has about 30 lamps. We assume 45% are incandescent (incl. halogen), 30% CFL, 25% LED (informed by a RIS that estimated in 2015, LEDs only made up about 20% of the residential lighting stock in NZ).
- LED provides about 85% saving* for incandescent replacement, and about 40% saving for CFL replacement
- We assume only 25% of a household's lights are on at peak time, and that there is 5% diversity between houses (i.e. 5% of households have no one at home during peak). This gives an average household 'after diversity' technical saving potential of about 0.3 kW/house
- Using this approach, we've estimated the total likely household lighting savings:
  - Technical potential of lighting savings is about 500 MW
  - Economic potential is about 70% of technical potential, or 350 MW
  - Realisable potential is about 15% of economic potential or 50 MW

* The efficiency of LEDs vary, but the technology is still improving (and the lower the lumen output, the more efficient the LED)

NZ versus consumer costs through day/year

- These costs are indicative only (varies by network)
- End-uses such as lighting that are mainly (but not solely) on at peak typically have an effective cost of more than 30c/kWh, but the variable tariff paid by consumers is below this (e.g. some down to 16c/kWh)

(To estimate the 'true cost' of an end use, we need to combine this chart with the hours of use of the appliance over the day/year, and allow for hours in each segment e.g. peak).



Lighting efficiency – economic benefit (indicative)

concept

- Previously we calculated the peak saving from the 30 lamps in the ‘average’ house as about 0.3 kW/house
- But what is the overall value of savings from an individual lamp replacement (i.e. from kW, kWh, and CO_2 savings)?
- Given the assumptions in the table, the net savings to NZ Inc per LED lamp are of the order of $150/lamp when replacing a high-use incandescent.

	Incandescent	LED
Lamp input power (kW)	0.1	0.015
Lamp cost ($)	0.75	20
running cost (c/kWh)	30	30
Lamp use (hrs/day)	2.75	2.75
Energy use (kWh/year/lamp)	100.4	15.1
Running cost ($/year/lamp)	30.1	4.5

- The variable part of the residential electricity tariff is on average less than the marginal cost of providing electricity at peak times
- The savings to the householder are more like $75/lamp, and are lower than the NZ Inc savings

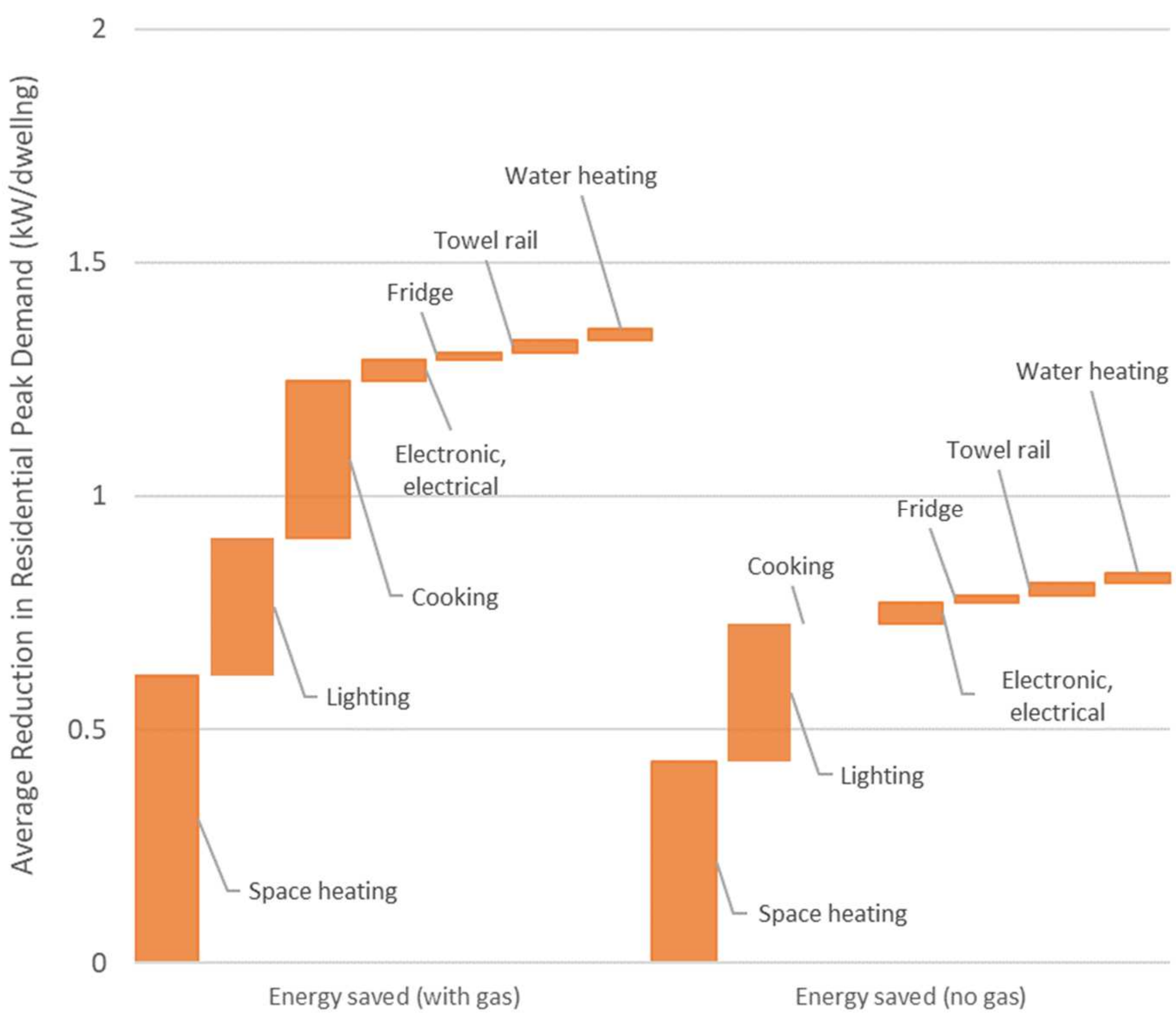
Why does this matter?

- Consider recessed incandescent downlights
- These are a significant source of inefficiency:
  - Lighting efficiency is less than a normal incandescent (directionality)
  - Ceiling insulation is significantly compromised
  - Likely to be many existing houses with this issue (although largely resolved for new builds)
- For a consumer, given the need for an electrician to replace fittings etc., often marginal benefit (or net cost) to replace recessed downlights with LEDs
- But, from a national viewpoint, even if we assume LED downlights are very expensive (e.g. up to about $120 per fitting to allow for new fitting and the electrician), they are economic in medium and high-use areas
- So, the mis-pricing of electricity may result in us foregoing a significant lighting efficiency gain (that also results in a space heating efficiency gain)

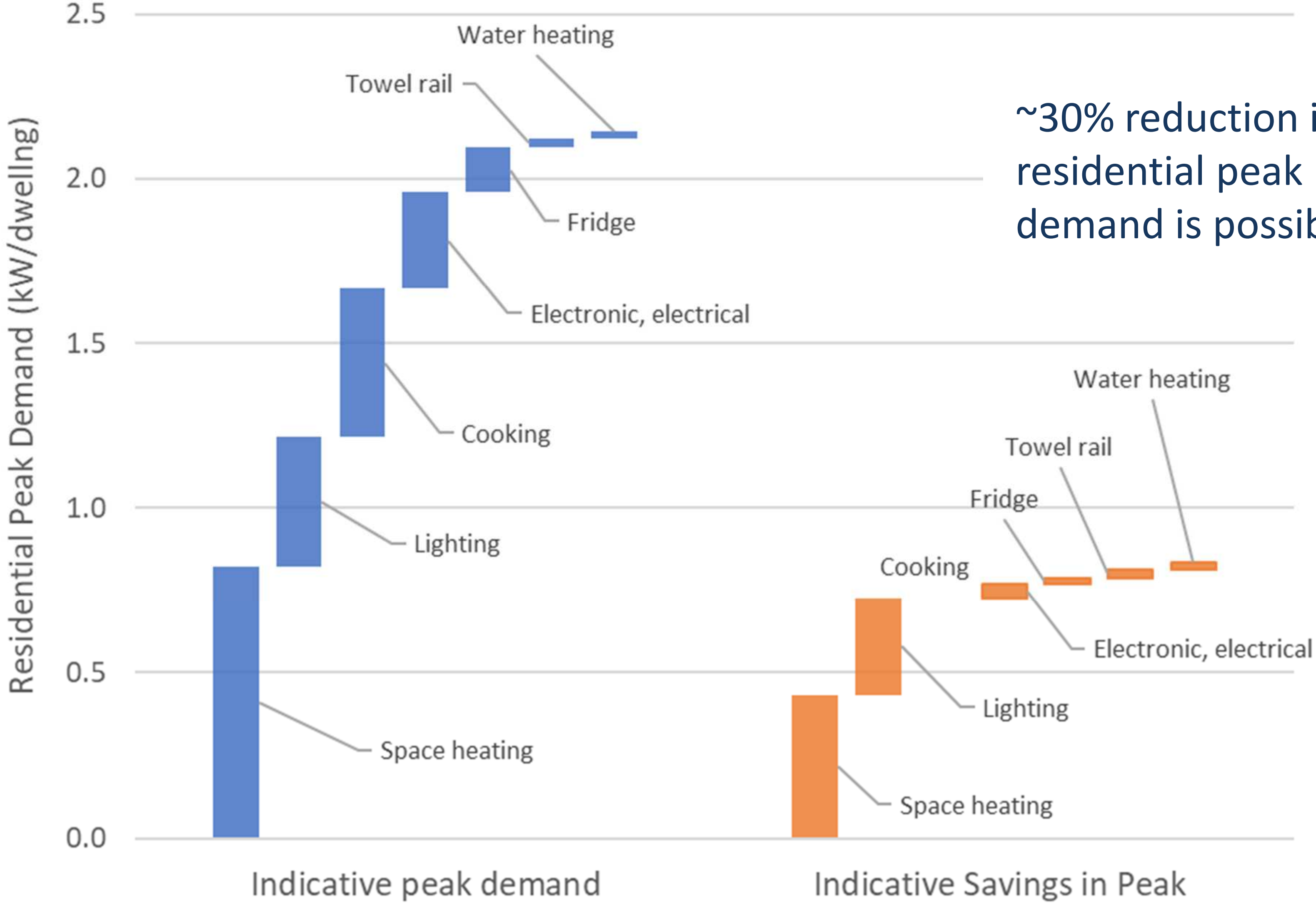
Lighting is only one area of potential gain – there are others

- Technical potential to reduce residential peak demand estimated at more than 0.8 kW/house

- Even greater potential if some demand is switched to gas (heating, cooking)



Peak demand versus technical savings potential



~30% reduction in residential peak demand is possible

Results are sensitive to key assumptions

- Issues to account for include:
  - mix of the existing technologies (LED, CFL, incandescent R80 etc.)
  - hours/day, and seasonality, of use
  - ‘real world’ heat-pump COPs on cold winter evenings
  - additional insulation benefits when changing from uncovered/unsealed downlights to sealed/covered down lights etc.

- However, the potential gains are clear for some appliances/technologies

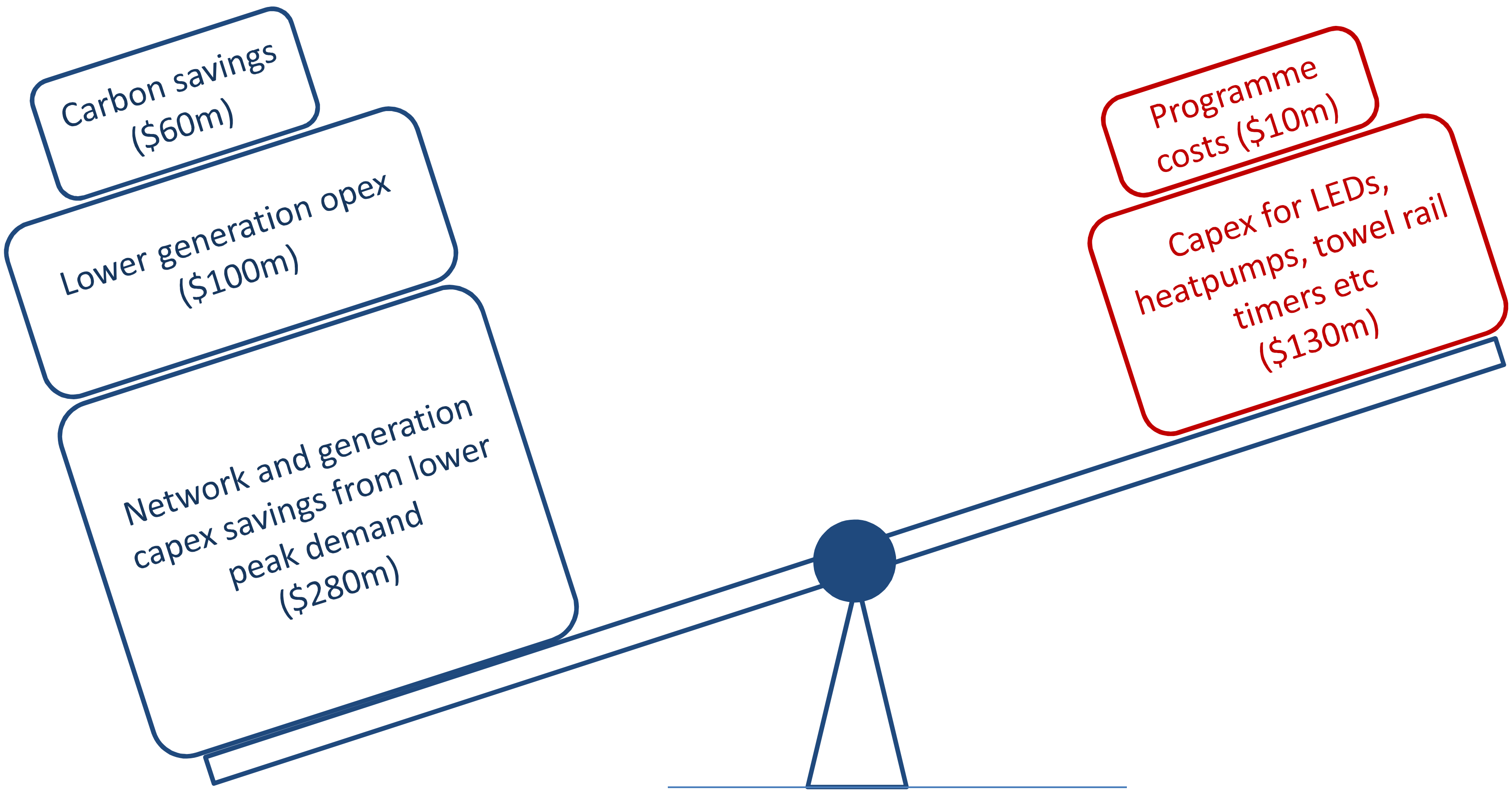
Potential savings (technical, economic and realisable)

Our potentials analysis is probably conservative for overall savings:

- Technical potential ($500m/yr) only looks at the residential sector, and excludes some available technologies such as thermal insulation, gas/wood space heating, efficient shower heads etc.
- Assume that 30% of this technical potential is uneconomic (giving an economic potential of $350m/yr - but note that we have focused technical potential only on the most economic options)
- Assume only 15% of economic potential can be realised i.e. only 10% of the original technical potential will be realised ($50m/yr)
- And finally, to calculate the overall value of net-benefits, we account for the need to ramp-up a new programme. We based our estimate on ramping up to the realisable potential over 6 years (i.e. from zero to the full realisable potential)

Estimated realisable net benefits of ~$300m in EE

The indicative NPV of the realisable net-benefits (over the next ten years) is about $300m



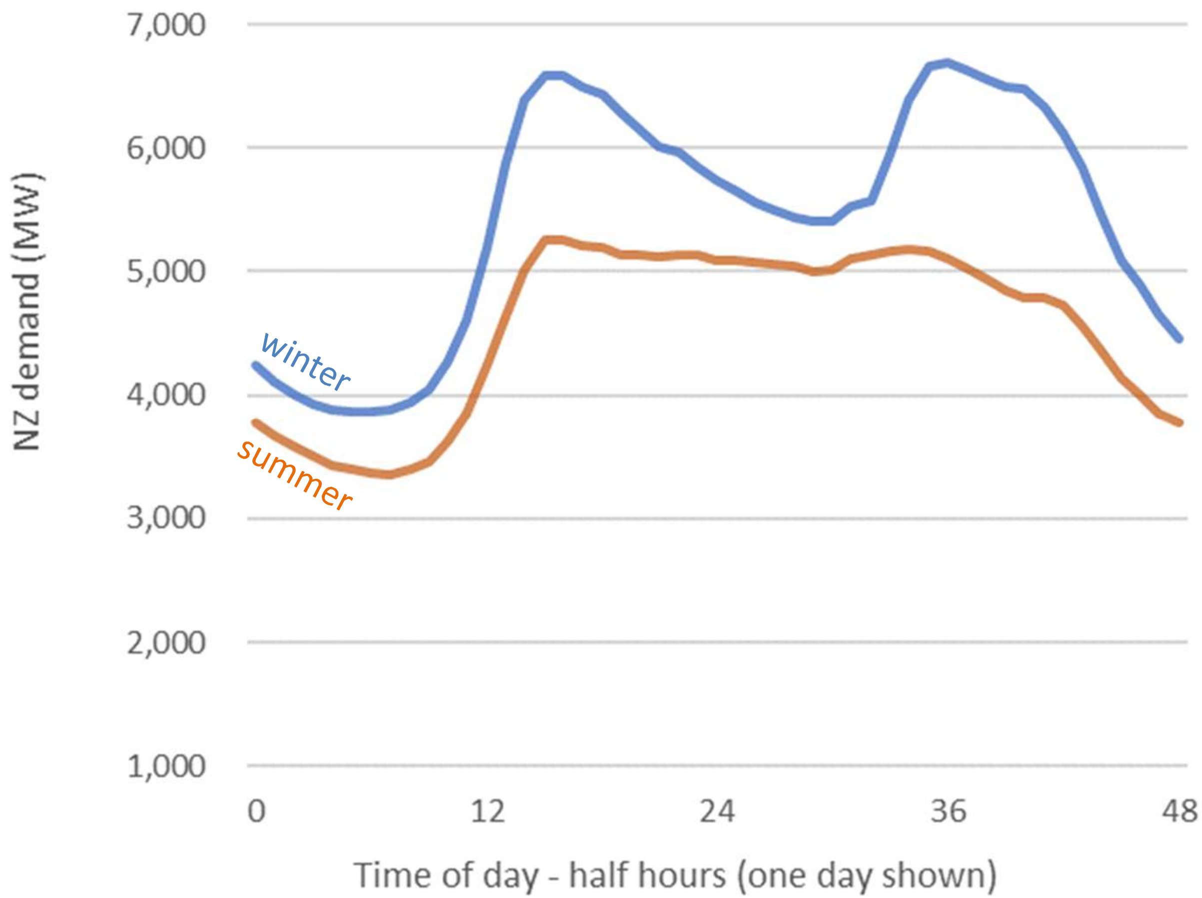
Uncertainty re 'peak savings'

- Some electricity distribution networks either have significant excess capacity, or flat/shrinking demand
- Therefore, recommend further work be undertaken to estimate scope for peak savings (e.g. analysis of network demand growth)
- Issues such as EVs and other factors need to be considered (some EV's will be charged at peak, but EVs will also reduce the day/night differential in demand)
- Overall, expect peak savings will be particularly beneficial, but more analysis of the specific programme-level benefits would be sensible

Environmental benefits – carbon

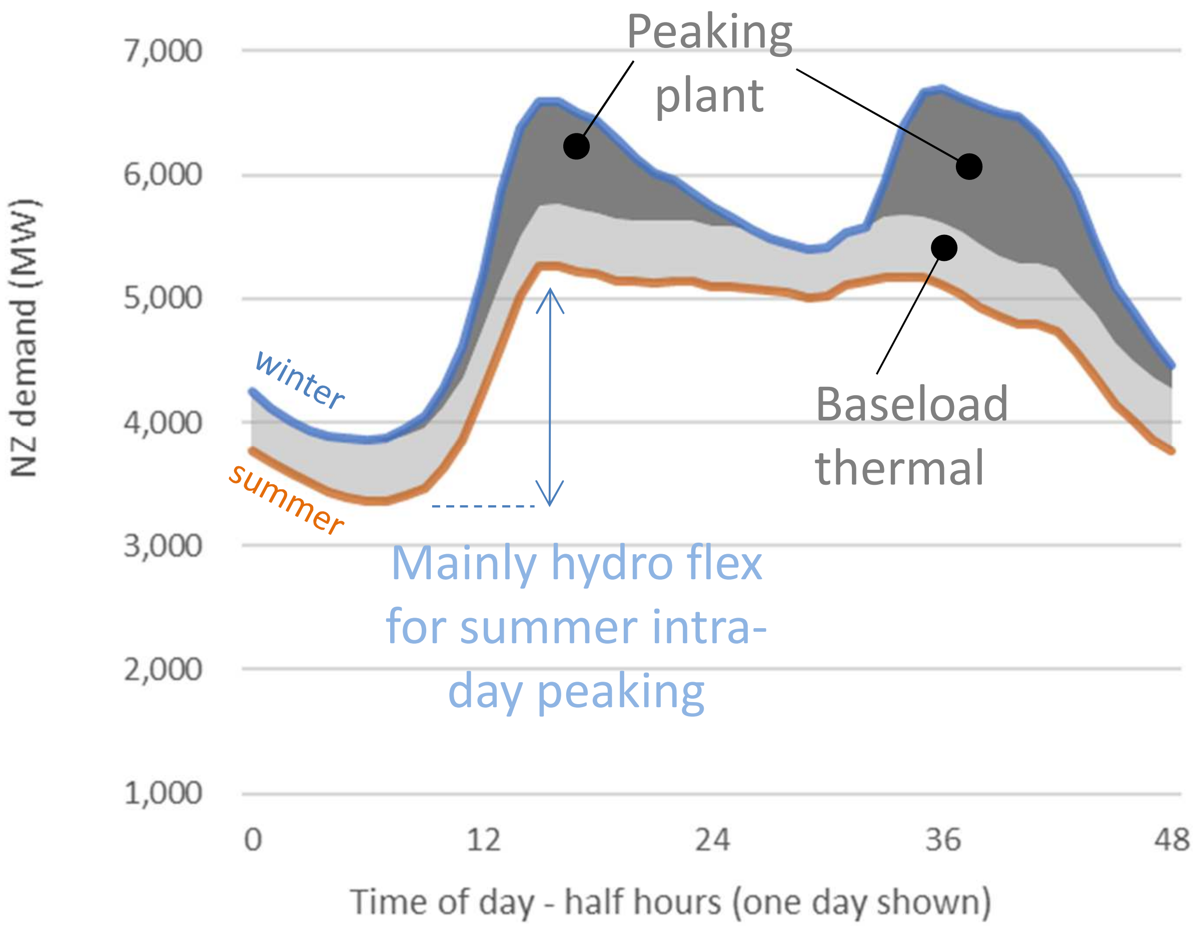
Will EE provide carbon savings?

- Carbon intensity of providing electricity varies depending on when it is required
- Carbon value of EE to NZ will vary depending on nature of reduction in electricity demand
- Winter peak demand tends to have a substantially higher carbon intensity than summer demand (except in dry summers!)



Carbon benefits from EE

- Base demand is met by geothermal, wind and unstoreable hydro
- Peaks are met by hydro initially, but once hydro capacity is reached, thermal is needed
- Baseload thermal generation (e.g. CCGT) has limited flexibility, but is more efficient (less carbon)
- Peaking thermal generation (e.g. OCGT) has lots of flexibility, but is less efficient (more carbon)



Peak-related GHG emissions

- Residential lighting and space heating largely responsible for the winter peak in demand (and much fossil fuel generation)
- Therefore, efficiency gains from residential lighting and space heating can result in reductions in fossil fuel use, and hence carbon savings
- We've estimated emission factors for winter peak demand (based on range of hydrological, and demand, and generation scenarios)
- We estimate that capturing the full technical potential of peak-related electricity efficiency could reduce electricity emissions by about 34% (or about equivalent to 1,700 ktCO_2e/year)
- If valued at $60/t$CO_2$e, the realisable carbon savings represent around 13% of the total benefits referred to in previous section

Non-peak GHG emissions

- Electricity generation at non-peak times also produces some GHG emissions
- However, emissions intensity at these times is generally lower than for peak periods
- That said, geothermal GHG emissions exceeded those from coal-fired power for first time in 2016

Social benefits

Social benefits from EE

- Many houses are known to be under-heated (due to the house being too 'leaky' to heat effectively with the available appliances, and/or due to the high cost of heating)
- There are known health benefits arising from maintaining adequate indoor air temperatures in houses (4 to 1 benefit to cost ratio)
- Electricity efficiency helps to make heating more effective AND affordable
- People typically get either a health benefit or a cost saving (i.e. not both) from insulation and heating programmes
- An electricity efficiency programme targeting health benefits through insulation and heating could be considered an example of the 'investment approach' to social issues


Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme

Arthur Grimes[1], Tim Denne[2], Philippa Howden-Chapman[3], Richard Arnold[4], Lucy Telfar-Barnard[3], Nicholas Preval[3] and Chris Young[1]

Role of EECA versus other arms of govt

- Some may argue that electricity efficiency that gives rise to health benefits should be a health-led programme
- However, the intervention is typically so energy technology specific that it requires specialist expertise that the health sector doesn't have (cf Australian deaths associated with their insulation upgrade programme)
- Further, EECA's Act acknowledges that efficiency is not only about energy reduction, but also increased service levels from energy use
- Basically, we need to discern between the *impact* and the *outcome*; where the *impact* is energy related (i.e. electricity efficiency) there's a role for EECA regardless of where the *outcome* arises (e.g. health)
- This is because of the technical complexity of energy and housing issues

What kinds of action make most sense?

Preferred areas for action

- Largest benefits for NZ from flattening/reducing peak demand
  – greatest electricity system and carbon benefits
- But all EE improvements will have some value, as electricity is a relatively high cost energy source
- Suggested areas of focus:
  i. Target low incremental cost, high impact peak reductions first (lighting, getting electric water heating off-peak etc.)
  ii. Target energy services which have a flatter use profile, but large potential savings (timers for appliances and underfloor heating etc.)
  iii. Target space heating – significant analysis may be required here to identify the best options and interventions as this will be very sensitive to any changes to distribution pricing
  iv. Target the flatter profile energy services (e.g. refrigeration) last – these may have lesser private benefit under new distribution pricing.

Preferred type of action

		Public net benefit (NZ perspective)	
		Yes	**No**
Private net benefit (consumer perspective)	**Yes**	• Information • Active promotion	• Provide information if it can be done at low cost
	No	• Standards/regulation • Financial support	• Do nothing – except perhaps provide information to prevent poor decisions

Where public benefits > private benefits, there will typically be insufficient uptake of EE, and vice versa

Won’t consumers act wisely where private benefits exist?

- **Poor signals/externalities**
  - Electricity price signals not cost-reflective – reform expected to take at least 10 years (e.g. transmission pricing)
  - Carbon mis-pricing expected to reduce, but could remain material for foreseeable future
- **Transactions costs and information issues**
  - Complex trade-offs required – especially re future costs of power and carbon - hard for consumers to evaluate limited and conflicting information
  - EECA able to lower transaction costs associated with access to information
- **Behavioural issues**
  - Extensive economic literature indicates many consumers make poor EE decisions – due to choice overload, loss aversion, hyperbolic discounting etc.
- In summary, good evidence to show that ‘do nothing’ option unlikely to produce best outcomes for NZ or consumers

Avoiding costs may be as important as encouraging benefits

- There's about 45 MW of grid connected residential solar PV in NZ currently
- This is more expensive than alternative generation options (from NZ Inc viewpoint)
- Net cost to NZ Inc is estimated at about $7,000 per 3kW PV system
- So, the net cost of solar PV to NZ (so far) is about $100m (from ~$145m invested)
- Costs currently fall disproportionately on those that don't invest in solar PV (which includes many vulnerable consumers)
- It's also a lost opportunity, the $140m invested into solar PV could instead have insulated about 50,000 homes (or delivered other valuable peak savings as discussed earlier) which would have resulted in a net-benefit, not a net-cost
- It's not just about consumer choice, it's about <u>informed consumer choice</u>

Summary/conclusions

Summary of findings

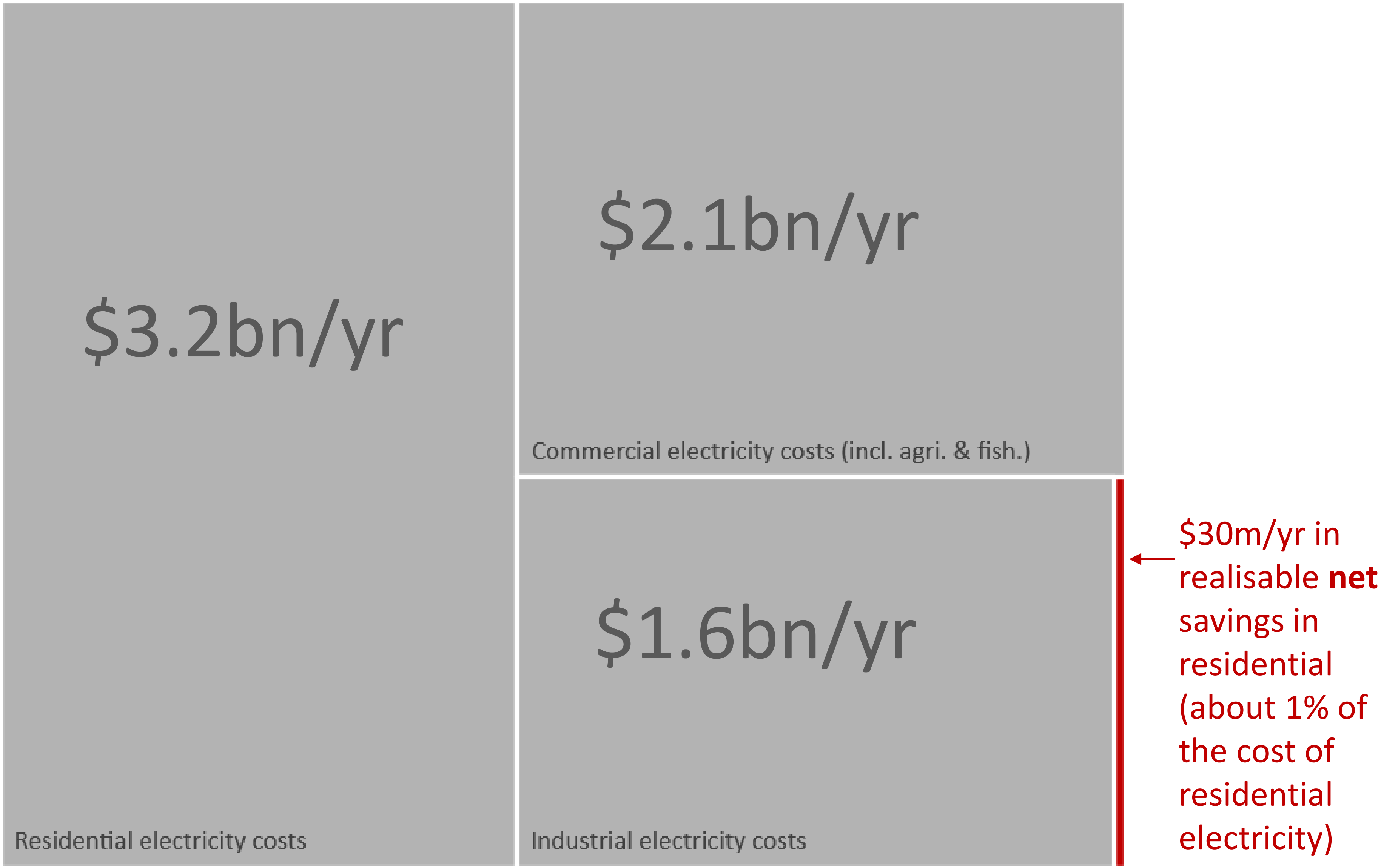
- Electricity efficiency (EE) matters
  - Electricity is costly to produce & transport
  - Costs particularly high in peak demand periods
- Potential economic benefits from EE (only residential sector considered)
  - Estimated at $300 million in net terms over 10 years
  - Equates to 6% of estimated technical potential
- Why won't these benefits be realised without action?
  - Externalities: mis-pricing of power and carbon
  - Consumer inertia/confusion, principal-agent issues & transaction costs
- Estimates exclude potential additional benefits in non-carbon environmental and social areas – not possible to quantify these within scope of our engagement

Summary of findings (cont'd)

- Other unquantified potential benefits
  - Commercial/industrial user demand excluded from estimates
  - Switching process heat from fossil fuel to electricity (new tech)

- Issues for EECA to consider
  - Appears that significant efficiency benefits remain to be captured
  - Key challenge likely to be proving the realisability of program actions
  - Recent changes to allow customers to obtain their TOU data provide increased scope for targeting and measuring benefits

Electricity costs versus est. residential savings ($/yr)



About Concept

- Concept is a specialist energy and economics consultancy that provides services to clients in New Zealand, Australia and the wider Asia-Pacific region.
- Concept provides advice on energy sector policy, business analysis, restructuring, market design, regulatory issues, energy modelling, market analysis, and technical issues.
- Combining economic rigour, leading modelling & analytical skills, and practical backgrounds in the energy sector, Concept consultants are able to provide practical solutions to client problems based on robust analysis.
- For more information, visit www.concept.co.nz or email info@concept.co.nz .

Disclaimer

- The information and opinions expressed in this presentation are believed to be accurate and complete at the time of writing.
- However, Concept and its staff shall not, and do not, accept any liability for errors or omissions in this presentation or for any consequences of reliance on its content, conclusions or any material, correspondence of any form or discussions arising out of or associated with its preparation.

www.concept.co.nz