Submission to the

Essential Services Commission Inquiry into the true value of distributed generation: Proposed Approach Paper

Melbourne Energy Institute
February 2016

Introduction

The Melbourne Energy Institute (Institute) welcomes the opportunity to provide comment on the *Essential Services Commission Inquiry into the true value of distributed generation Proposed Approach Paper*.

The Institute brings together the work of over 150 researchers, across seven faculties at The University of Melbourne , providing international leadership in energy research and delivering solutions to meet our future energy needs. By bringing together discipline-based research strengths and by engaging with stakeholders outside the University, the Institute offers the critical capacity to rethink the way we generate, deliver and use energy.

The Institute presents research opportunities in bioenergy, solar, wind, geothermal, nuclear, fuel cells and carbon capture and storage. It also engages in energy efficiency for urban planning, architecture, transport and distributed systems, and reliable energy transmission. Economic and policy questions constitute a significant plank of the Institutes research program and include: market regulation and demand; carbon trading; energy system modelling; climate change feed backs; and social justice implications of energy policy.

This submission addresses four main areas raised for consultation in the proposed approach paper. Summary points can be found on page 2. We thank you for the opportunity to provide comment to this process and please do not hesitate to contact us at the Melbourne Energy Institute on 03 8344 3519.

Contents

Summary

Approach

- We agree that the true value of distributed generation should capture, *'as accurately as possible, the total benefits produced by [distributed generation] investment'*.
- We recommend a consistent approach to the inquiry, with public benefit and value to *consumers* remaining central to *both* parts of the inquiry.
  - Considering only the *'value to the distribution (and transmission) businesses'* with respect to network value is inconsistent and not likely to promote socially optimal levels of investment.
- Limiting the inquiry to *easily quantifiable* values will not capture the total public value of distributed generation, and ultimate not promote socially optimal levels of investment.
- Establishing a stakeholder reference group that is broadly representative of the stakeholder groups identified by the Commission may enable more effective and extensive consultation.

Definition of 'distributed generation'

- Both demand side management and distributed generation reduce energy drawn from centralised generation and have the potential to reduce network demand, and the distinction between them and the value they provide is arbitrary and inequitable.
- An equitable and consistent definition of distributed generation will not discriminate between energy sources and (if included) will not discriminate between different forms of demand side management.
- Battery storage is not strictly a form of distributed generation. The exclusive inclusion of battery storage above other demand side management options is unjustified and inconsistent.

What other values can be attributed to distributed generation?

- Health and other benefits (beyond carbon reductions) can be attributed to distributed generation
- A value of distributed generation is provision of an essential service, similar to and in competition with network business. This is distinctly different to creating *'value to the distribution (and transmission) businesses'*.
  - A subset of this includes reduced bushfire risks.

Key issues for the inquiry

- While the spot market does provide price signals (e.g. time of day), it does not necessarily capture the full market value of energy.
- The Renewable Energy Target does not sufficiently reflect the environmental value of distributed generation.
  - In addition, incentives paid through the Small-scale Renewable Energy Scheme will begin phasing out from 2017
- Alternative methods exist to quantify environmental value. The Social Cost of Carbon is a widely used methodology for valuation of the estimated damages associated with an incremental increase in carbon dioxide (or equivalent) emissions in a given year.

1 Commissions approach

The Institute broadly supports the approach proposed by the Energy Services Commission (Commission)[1]:

- *Define distributed generation for the purposes of this inquiry.*
- *Determine what values can be attributed to distributed generation and whether methodologies exist to enable the calculation of these values.*
- *Understand how the regulatory framework accommodates the value of distributed generation.*
- *Identify any regulatory changes needed to improve the framework for valuing distributed generation.*

'True Value'

We agree with the Commission's view that the true value of distributed generation should capture, *'as accurately as possible, the total benefits produced by [distributed generation] investment'*[2]. The focus on the three elements of public benefit (economic, environmental and social) identified by the Commission are appropriate given the terms of reference. The Institute also agrees that only through including the total benefits will this inquiry *'support the development of efficient payment structures that promote the socially optimal level of investment in distributed generation'* [2].

The Commission's approach across the entire inquiry does not seem be consistent with this focus, however. On one hand, the Commission has proposed that the 'energy value' represents the *'value to other consumers of having electricity produced by a distributed generator'*[3]. The 'network value', on the other hand, has been more narrowly defined to represent the *'value to the distribution (and transmission) businesses'*[3]. One part of the inquiry will consider the value to *consumers*, and the other the value to *network businesses*. Whilst splitting the inquiry is sensible given the complexity of the task, we do not see reason for using different definitions for 'value' for the two components. Additionally, considering only *'value to the distribution (and transmission) businesses'* with respect to network value is unlikely to lead to socially optimal levels of investment in distributed generation.

The primary function of the Commission is to provide *'incentives for dynamic, productive and allocative efficiency and promotes the long term interests of Victorian consumers'*[4]. Similarly, the highpoint of reference for policy in the national electricity system, the National Electricity Objective (NEO), as set out in the National Electricity Law, is to *'promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers'*[5]. Given the primacy of the consumer to both the Commission and the legislation underpinning the electricity sector, it is appropriate that the public benefit and value to *consumers* remain central to both parts of the inquiry.

Value quantification

The proposed approach paper implies that public benefits that are not *'easily quantifiable'*[6] have been excluded. We argue that this is not a legitimate rationale for public benefits to be discounted.

[1] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 2.
[2] Ibid., page 3.
[3] Ibid., page 2.
[4] The Parliament of Victoria, *Essential Services Commission Act 2001*.
[5] The Parliament of South Australia, *National Electricity (South Australia) Act 1996*, Section 7, National electricity objective.
[6] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, pages iv, v & 19.

The Terms of Reference specifically directs the Commission to consider values that are generally and historically not easily quantifiable (namely environmental and social value). One reasons such values are not easily quantifiable (in monetary terms) is that market prices fail to reflect true costs and benefits, or that that no markets exists. Indeed it is precisely because of market failures and that such externalities exist that an inquiry in the true value of distributed generation is needed. Market signals alone would be enough to encourage socially optimal investment if this were the case.

While it might not be possible to perfectly accurately capture the monetary value of some public benefits, the Institute agrees that all benefits should be quantified *'as accurately as possible'*[7]. The Council of Australian Governments provides some guidance on dealing with these 'intangables'[8]:

> *'Inevitably, some costs and benefits resist the assignment of dollar values. Known as 'intangibles', these are separately presented to decision-makers for assessment in conjunction with those that can be quantified.'*
>
> ***COAG, 2007***

As indicated by the Commission, this inquiry will investigate the value of distributed in order to support the development of payment structures that promote the socially optimal level of investment in distributed generation. We argue that the limiting the inquiry to 'easily quantifiable' values will not capture the total public value of distributed generation, and ultimate not promote socially optimal levels of investment.

Risks and Costs

The Commission has indicated that unwarranted investment in Distributed Generation will have *'potentially costly consequences'*[9]. While we agree with this view, the reverse is also true: insufficient investment in distributed generation is also potentially costly, from a system-wide perspective. By definition, under-investment implies a level of distributed generation that is sub-optimal from both a society and system wide perspective.

Additionally the risk of these costs are asymmetrical, particularly with respect to public benefit. As noted by the Lancet Commission in 2015, many climate change mitigation efforts are *"no-regret"* options leading to direct reductions in the burden of ill-health enhance community resilience among other things[10].

VCEC Inquiry

We note that the Commission refers to the previous Victorian Competition and Consumer Commission (VCEC) inquiry[11]. While this inquiry provides a useful staring point, we would stress that the Terms of Reference are materially different. The VCEC inquiry was required to (emphasis added)[12]:

1. Assess the design, efficiency and effectiveness of *feed-in tariff* schemes
2. Provide a recommendation as to whether existing *feed-in tariff* arrangements should be continued, phased-out or amended.
3. Identify and State and/or local regulatory and other barriers to the development of a network of distributed renewable and low emission generation in Victoria

VCEC 2012

[7] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 3.
[8] COAG, *Best Practice Regulation*, page 21.
[9] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 3.
[10] Watts et al., "Health and climate change".
[11] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 8.
[12] Victoria and Victorian Competition and Efficiency Commission, *Power from the people*, see pages vii-viii for full Terms of Reference.

This is fundamentally different to determining the *value* of distributed generation, particularly with respect to the environmental and social value.

Consultation

The Terms of Reference request that *'the inquiry [..] involve extensive consultation with industry, environmental organisations and consumer advocacy groups'*[13] . We recognise that some stakeholders or stakeholder groups maybe adversely affected by this inquiry and it's recommendations, and support extensive consultation.

However we also note there is no explicit stakeholder engagement processes outlined in the Proposed Approach Paper, and there is a concern that important stakeholders will be overlooked or neglected. The recent invite only stakeholder workshop in Melbourne provides a salient example. No consumer advocacy groups were present, and only one environmental organisation was (briefly) present. Other stakeholders to consider include (but are not limited to) the Victorian Council of Social Services, the Alternative Technology Association and the Consumer Utilities Advocacy Centre.

Establishing a stakeholder reference group that is broadly representative of the stakeholder groups identified by the Commission may enable more effective and extensive consultation.

2 Definition of 'distributed generation' for the inquiry

There are many different definitions of 'Distributed Generation'. Most commonly, it refers to energy generation that is produced close to the point of consumption, rather than delivered long distances over transmission lines from centrally operated power stations[14].

The Institute recognises that the Commission is bound by Terms of References to examine the the value of 'distributed generation'. We would like to note that impact of 'distributed generation' on the operation of the power system is similar, if not indistinguishable, to other Demand Side Management (DSM) strategies. DSM strategies include (but are not limited to), energy efficiency, load shifting, thermal storage, and dynamic demand response. Both DSM and distributed generation reduce energy drawn from centralised generation and have the potential to reduce network demand, and from a system perspective the distinction between them and the value they provide is arbitrary and arguably inequitable.

Distributed Generation - both sides of the meter

The Commission is *'proposing to look at the value of the total output of distributed generation to both the electricity market and the distribution network'*[15]. The Intitute welcomes this approach, as the value of distributed generation is largely independent to what side of the meter the generation is on, particularly for small-scale distributed generation.

Given that the inquiry is proposing to look at the total value of distributed generation, it does not make sense for the Commission to distinguish between energy that is exported to the grid, and energy that is used to meet demand locally. This distinction *is* highly relevant for distributed generation system owners, with both the tariff structure for consumption and export having a significant impact on the economic performance of an investment. However, it is unnecessary to make this distinction in determining 'true value' from a societal perspective, and price distortions in existing consumption tariffs complicate the analysis.

The Institute also supports the decisions to include all fuel sources in the inquiry. However, it is not clear this definition extends to non-electric distributed energy generation. This includes Solar Hot Water (which make use of solar thermal energy) or Air Source Heat Pumps (which makes use of renewable ambient energy). Excluding these effectively narrows this definition to 'distributed *electricity* generation' and requires justification, as the impact

[13] Robin Scott MP, Minister for Finance, *Terms of Reference*.

[14] See Productivity Commission, *Electricity Network Regulatory Frameworks*, page 502 & 503 for different definitions of distributed generation.

[15] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 13.

on the system is similar, if not indistinguishable from electric generation. This similarity is reflected by the fact that both Solar Hot Water and Air Source Heat Pumps are eligible for small-scale technology certificates within the renewable energy target (RET) scheme.

Storage is not 'distributed generation'

We do not support the decision to exclusively include battery storage within the Commission's definition for 'distributed generation' within this inquiry. As noted by the Commission itself, *'battery storage is not strictly a form of generation'*. Small-scale battery storage is more accurately characterised as a DSM technology. More generally, storage *shifts* energy (consumption or production) but does not generate itself. This is similar to other DSM technologies, which have not explicitly been included in the inquiry.

The Commission has justified including battery storage by arguing that a *'battery storage system can supply electricity and as such operates in the same way as a generator'*. However, as noted both above and by the Commission itself, it is the *total* impact on the system that determines value, and not the energy that is consumed locally or exported to the grid. When considering this point, the distinction between battery storage and other forms of DSM becomes meaningless. Load shifting, thermal storage or other demand responses are indistinguishable from battery storage. Batteries may help in *'reducing the host consumers need for electricity to be supplied along the network'*, as might these other DSM strategies.

Battery storage and other DSM management technologies have the potential to provide significant public benefit and value (particularly with regards to the network). However, given the Commission is investigating the *total* value, (rather than export and local value) the exclusive inclusion of battery storage above other DSM options is unjustified and inconsistent.

Other Definitions

A wider investigation involving all forms of 'Distributed Energy Resources' (including Distributed Generation, and all forms of DSM) would be welcome. However this would require modification to the Terms of Reference, and would require additional work.

Excluding this option, an equitable definition will not discriminate between energy sources, and (if included) not discriminate between different forms of demand side management. The definition provided above is non-discriminatory and equitable:

> 'Distributed Generation' commonly refers to energy generation that is produced close to the point of consumption, rather than delivered long distances over transmission lines from centrally operated power stations.

3 What other values can be attributed to distributed generation?

There are several public benefits that the Commission did not identify, or incompletely captured in their proposal. The health benefits are a particularly noteworthy omission. In this section we describe additional values of distributed generation, and how these are quantified.

3.1 Health value

One significant social value is a reduction in the health burden of the emission from fossil generation. A study by the Australian Academy of Technological Sciences and Engineering (ATSE) in 2009[16] provided an early estimate of both the health and emissions related costs of fossil generation in Australia. A key message of this report included *'These costs can be significant compared with conventional operating costs'*[17].

[16] Biegler, *The hidden costs of electricity*.
[17] Ibid., page 12.

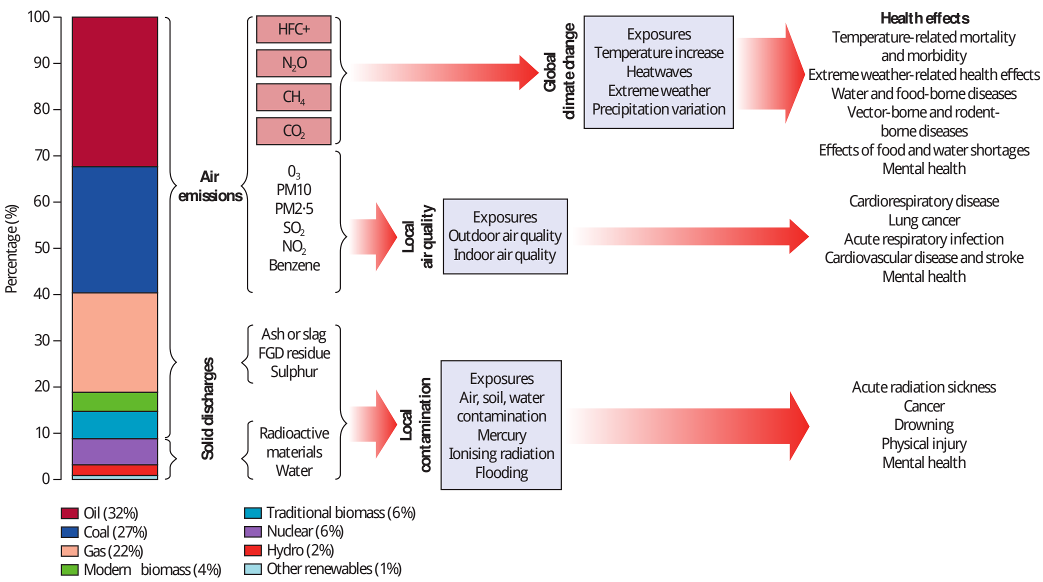

Figure 1: Connection between the energy system and health impacts[22]

This health value is related to and linked with such avoided carbon emission and reduction in climate change impacts. Future projections of climate change represent an *'unacceptable high and potentially catastrophic risk'* to human health[18]. Efforts to reduce the impacts of climate change will also have long term health benefits from the direct and indirect effects of climate change. In addition to this, the so-called direct 'co-benefits' of carbon reduction activities also have significant health benefits. Indeed the Lancet Commission suggests that addressing climate change *'could be the greatest global health opportunity of the 21st century*[19]. Figure 1 illustrates the direct and indirect health affects from current forms of energy.

Given the interdependence of emissions reduction and health, we suggest determining the health and environmental value of distributed generation together. One approach would combine the value of avoided direct (non-carbon) health costs with long term costs associated with increased carbon emissions. The Lancet Commission proposes a similar approach, with high level formula to account for the global impacts of emissions related to climate change, as well as their local impacts on human health and ecosystems.[20]. In this section we present the direct health benefits only. The environmental value and approaches that combine both health and environmental costs are covered in section 4.2 (see pages 14 & 15).

Direct health benefits

A reduction in emissions reduces air pollution and respiratory illnesses. Reduced coal emissions in particular can improve cardiovascular and respiratory health, by reducing particulate matter (such as $PM_{2.5}$) and pollutants such as sulphur and nitrogen oxides[21].

There are now several studies that have quantified the direct health impacts of emissions from fossil fuel generation in Australia. This includes the ATSE study, a recent international study published in Nature Climate Change[23], and a study from Harvard looked at the health

[18] Watts et al., "Health and climate change".
[19] Ibid.
[20] Ibid., see box 7 on page 1980.
[21] Biegler, *The hidden costs of electricity*, page 11.
[22] Watts et al., "Health and climate change", p. 1883.
[23] West et al., "Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health".

Table 1: Estimates of health cost of fossil generation in Australia

Study	**Scenario**	**Cost ($/MWh)**
ATSE[26]	-	$13.20
Harvard[27]	Low	$4.45
	Med	$7.94
	High	$14.83
West et. al.[28]	2030	$11.00
	2050	$21.00
	2100	$36.00

costs of a specific generator in Victoria (Hazelwood)[24,25]. A summary of the health costs evaluated can be found in table 1.

3.2 Competition with network service provision

Energy supply is considered to be an essential service (a basic service that few households can do without) and vital to maintain the standard of living of individuals and households. Historically, network services delivered this essential service, and have been considered 'natural monopolies' due to a variety of features including very large fixed costs (and low marginal operating costs)[29]. The supply of electricity costs are argued to be minimised through supply by a single distributor or transmission business, as it would be uneconomic for another business to duplicate the infrastructure[30].

As a result of this, network business are subject to detailed government price and other regulation. Without strong regulation, network businesses could be expected to set excessively high prices and potentially provide too low a quality of service[31], as the *'the usual competitive processes that weed out less efficient businesses are non-existent for regulated natural monopolies'*[32]

This no longer holds true: distributed generation also has the capacity to supply this essential service. That is, a value of distributed generation is provision of an essential service, similar to and in competition with network business, (undermining the monopoly position of network business. It is in part for this reason that determining the *'value to the distribution (and transmission) businesses'* is inappropriate when considered the network value of distributed generation. In fact socially and economically optimal investments in distributed generation and reductions in costs for all consumers may occur at the expense of network business. As recently noted:

> *'The falling costs of decentralised power and storage open up the possibility of reducing costs of power supply to users of power throughout the State. But only if the pricing of network infrastructure allows economically efficient use of the existing grid, and provides incentives for efficient allocation of investment between centralised and decentralised power in future.'*
>
> *'The first step towards rational pricing is to write down the value of redundant grid capacity of some investments that have been made redundant by technological*

[24] Ward and Power, *Cleaning up Victoria's Power Sector*.
[25] The current Hazelwood Mine Fire Inquiry may reveal additional information on the health costs associated with fossil fuel generation
[26] Biegler, *The hidden costs of electricity*, page 46.
[27] Ward and Power, *Cleaning up Victoria's Power Sector*, page 17.
[28] West et al., "Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health", Supplementary Information: Methods and Additional Results.
[29] Productivity Commission, *Electricity Network Regulatory Frameworks*, page 122.
[30] Ibid., page 121.
[31] Ibid., page 121.
[32] Ibid., page 12.

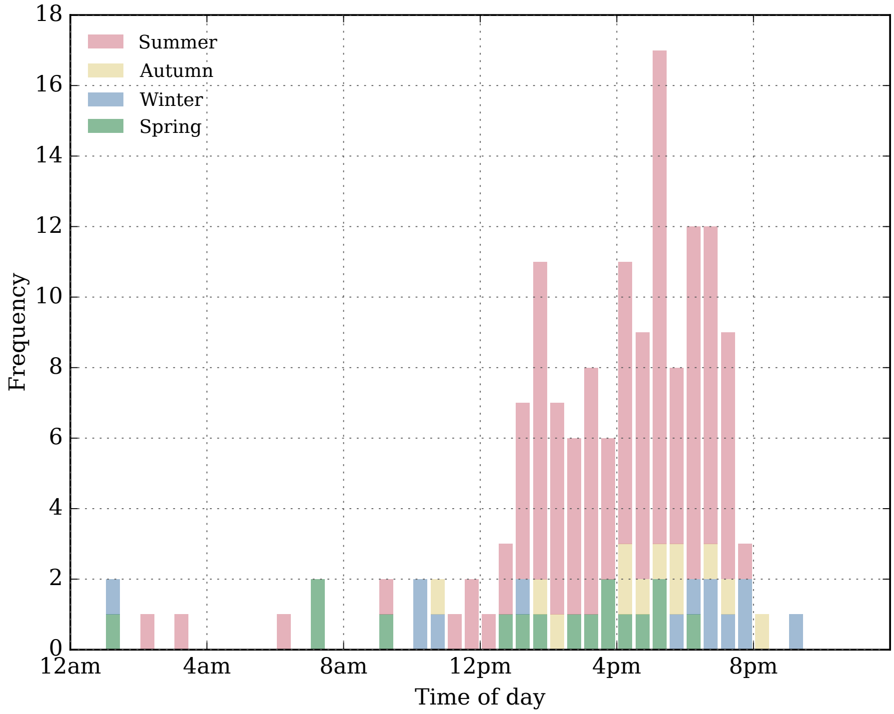

Figure 2: Distribution of network peak time for zone substations in Victoria[34]

> *and economic change, and others that were redundant when they were made. This is what the market economy forces in other sectors of the economy where there has been investment in supply capacity beyond demand.'*
>
> ***Ross Garnaut*[33]*, 2016***

In a competitive frame, the value of distributed generation could be be determined by the assessing the contribution of a distributed generator to network capacity, and particular network peak. Network costs are largely determined by the cost of meeting the network peak.

This network value would depend highly on the specific characteristics of the location of the distributed generation within the network, and the peak profile and timing of the peak in the relevant part of the network, and the characteristics of the distributed generation. Figure 2 illustrates the distribution of network peak times for zone substations in Victoria. Figures 3 and 4 illustrate the contribution of a particular distributed generation technology, solar photovoltaic, on the load duration curve for two zone substations with different load shapes (and peak load times).

[33]Garnaut, *Australia After Paris: Will we use our potential to be the energy superpower of the low-carbon world?*

[34]McConnell, "Capacity value assessment of distributed solar in the NEM".

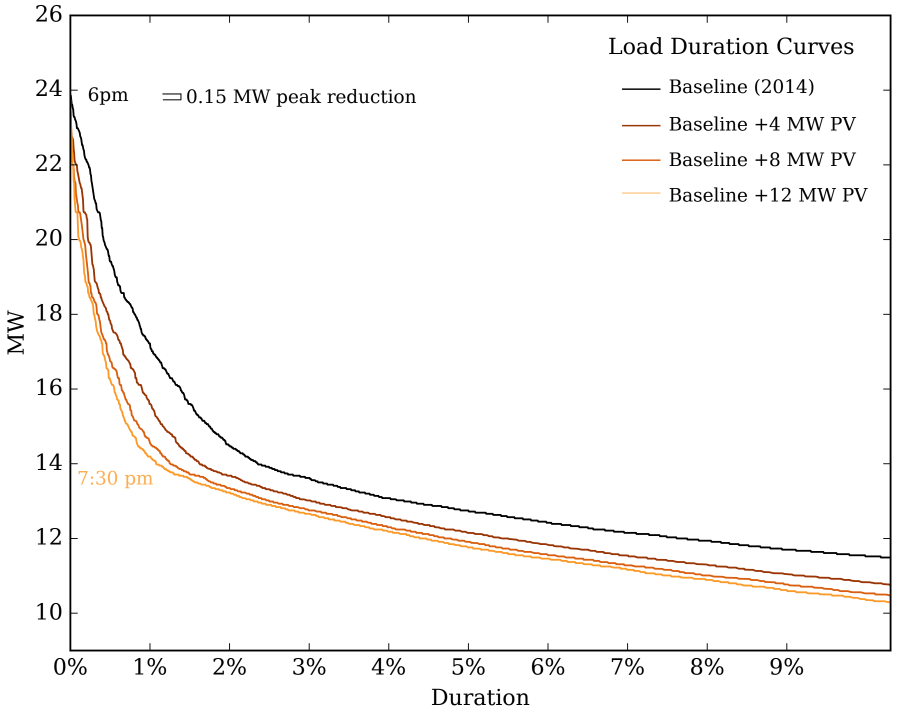

Figure 3: Impact of increasing penetration of solar on zone substation A

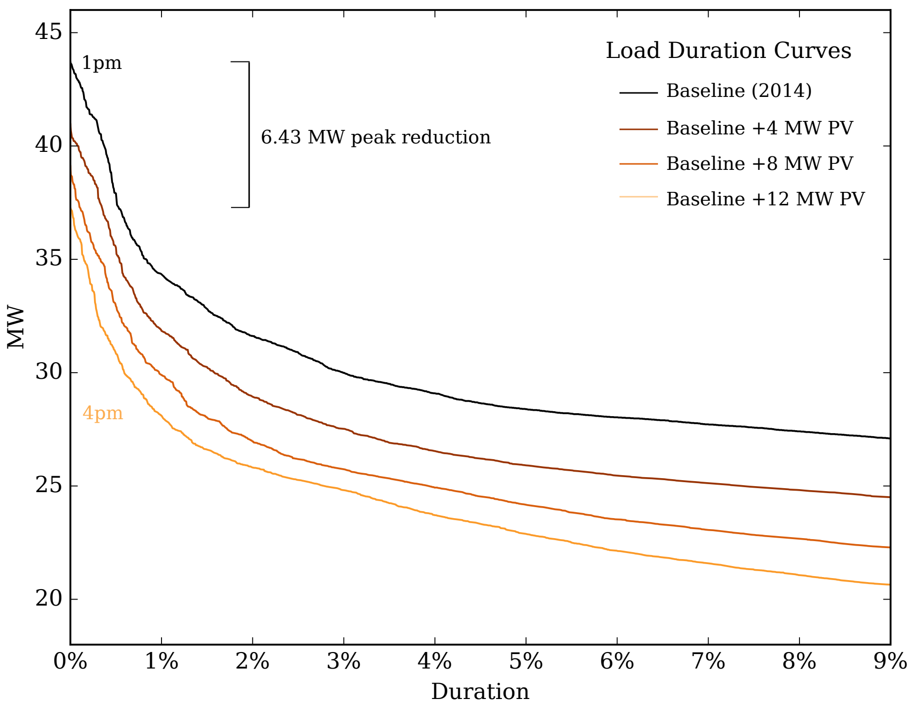

Figure 4: Impact of increasing penetration of solar on zone substation B

Bushfire mitigation

One notable are where this competition is particularly evident is in the area of bushfire mitigation. After the 2009 'Black Saturday' bushfires, which caused 173 deaths and in excess of $4.4 billion in damages, a Royal Commission concluded that five of the major fires were started by power lines[35]. The Commission found that *'The [Single Wire Earth Return (SWER)] and 22kV distribution networks constitute a high risk for bushfire ignition,along with other risks posed by the ageing of parts of the networks and the particular limitations of SWER lines* and made several recommendations, including:

> **Recommendation 27: progressive replacement of 22kV and SWER powerlines The State amend the Regulations under Victorias Electricity Safety Act 1998 and otherwise take such steps as may be required to give effect to the following:**
>
> - the progressive replacement of all SWER (single-wire earth return) power lines in Victoria with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk. The replacement program should be completed in the areas of highest bushfire risk within 10 years and should continue in areas of lower bushfire risk as the lines reach the end of their engineering lives
> - the progressive replacement of all 22-kilovolt distribution feeders with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk as the feeders reach the end of their engineering lives. Priority should be given to distribution feeders in the areas of highest bushfire risk.

The 'Powerline Bushfire Safety Taskforce' was established to recommend to the Victorian Government how to 'maximise the value to Victorians from the recommendations'. The taskforce investigated several options including under grounding power lines, insulating overhead power lines, deploying new protection technologies and stand alone power systems (allowing some lines to be permanently turned off)[36].

The taskforce estimated the costcost to underground powerlines in all non-urban areas in Victoria to be approximately $40 billion and to insulate all powerlines in non-urban areas is approximately $20 billion[37]. This compares to current regulated asset base of $13.6 billion for network service providers in Victoria[38]. However only 2% of non-urban electricity customers use 10% of powerline length and 50% of the states 'total fire loss consequence'[39] (4% of non-urban electricity consumers uses 20% of powerline length and 80% of the states 'total fire loss consequence'). The taskforce proposed six different packages with the 'largest relative risk reduction' (91%) costing $10 billion[40], and replacing 40,000km of power line.

The Victorian Government ultimately accepted a much smaller package (costing costing approximately $750 million in total). This included $200 to replace 1,000 km powerline (significantly smaller than the 28,060 km of SWER in Victoria[41], which was recommended to be removed by the Victorian Bushfire Royal Commission[42]).

The task force identified that one of most effective options to minimise the risk of powerlines starting bushfires is to turn off powerlines permanently, by providing customers with a stand-alone area power supply and removing the powerline that previously supplied them.[43]. If there is no powerline, there is no longer a risk that the powerline will ignite bushfires. However, at the time, standalone power systems were considered 'not suitable' due to the

[35] 2009 Victorian Bushfires Royal Commission, *Final report*.
[36] Energy Safe Victoria, *Powerline Bushfire Safety Taskforce - Final Report*, page 4.
[37] Ibid., page 5.
[38] Australian Energy Regulator, *State of the energy market 2015*, pages 68 and 69.
[39] Energy Safe Victoria, *Powerline Bushfire Safety Taskforce - Final Report*, page 3.
[40] Ibid., pages 7 and 9.
[41] Ibid., page 24.
[42] 2009 Victorian Bushfires Royal Commission, *Final report*.
[43] Energy Safe Victoria, *Powerline Bushfire Safety Taskforce - Final Report*, page 77.

cost. This was based on case study of 10 houses in 2010, with systems consisting of two 10kWh zinc bromine batteries, a 6kW inverter, either 3.2kW or 4.8kW of solar panels and a 7kVA back-up diesel generator and cost $120,000 dollars[44]. The case studies also had several difficulties with operation and system design.

Given that the cost of distributed generation (and off-grid generation solutions) have significantly dropped since 2010, the social cost of bushfires, and the cost of network solutions to reduce bushfire risks in remote areas - it would be worthwhile to revisit the value of distributed generation in mitigating bushfire costs and risks.

4 Key issues for the inquiry

4.1 Energy value

The Institute agrees with the Commissions view that the value of distributed generation varies significantly through out the day (and indeed through out the year. However, it is unclear why the Commission is considering the two options presented for determining this value. The IPART analysis looks at the time-of-use value of solar *exports* for its review of review of feed-in tarrifs, and had considerably different terms of reference. Specifically, it is limited to a single technology and a does not consider total value (just exported electricity).

The Institute would also caution against approaches that calculate energy value solely based on forecast spot market prices for each half-hour period. Evidence suggests that there is a discernible premium for contracted (rather than spot price) electricity purchases[45]. The table on 13 (figure 5) illustrates the spot average prices mean contract prices at a time theory would predict smallest difference between contract and spot prices[46].

This is particularly relevant when considering the merit order effect[47]. While the merit order effect is not novel or particular to solar photovoltaics or other distributed generators, the barriers to participate in futures markets or other contract arrangements for small-scale distributed generation are significant. A new large generator will also create the merit order effect, however it would usually be contract with a power purchase agreement or similar contract. If it was not (i.e. it were a merchant plant) it would likely bid more opportunistically and the merit order effect would be reduced. This is reflected in comments recorded in 'Forward contracts in electricity markets: The Australian experience'[48]:

> *"Sometimes you will get a new board member [argue that] our average contract rate last year was $40 and the average spot was only $27 why didnt we just take the spot? And we say yes, but it wouldnt be $27 if we werent contracted".*

While the spot market does provide price signals (e.g. time of day), it does not necessarily capture the full market value of energy. Alternative approaches might consider the futures market value (not only head spot prices).

The Institute would also note that spatial resolution of transmission and distribution loss factors are publicly available. Use of these would provide greater and more efficient locational price signals.

[44] Energy Safe Victoria, *Powerline Bushfire Safety Taskforce - Final Report*, page 163.
[45] Anderson, Hu, and Winchester, "Forward contracts in electricity markets".
[46] Ibid.
[47] See McConnell et al., "Retrospective modeling of the merit-order effect on wholesale electricity prices from distributed photovoltaic generation in the Australian National Electricity Market", for further discussion on the merit order effect with respect to solar PV.
[48] Anderson, Hu, and Winchester, "Forward contracts in electricity markets".

Table 3
Average spot prices and forward prices in NSW, QLD, SA and VIC

		NSW		QLD		SA		VIC	
		Forward	Spot	Forward	Spot	Forward	Spot	Forward	Spot
2003	Peak	50.01	35.54	49.94	29.41	56.25	34.50	54.42	30.86
	Offpeak	24.16	19.05	24.62	17.03	24.84	20.40	23.48	16.86
2004	Peak	45.47	65.19	41.44	46.94	54.19	52.47	43.01	38.91
	Offpeak	32.11	29.09	20.09	24.56	23.85	32.97	29.95	22.93
2005	Peak	52.66	54.13	53.30	34.31	61.78	44.21	47.01	33.98
	Offpeak	25.22	21.25	23.38	17.91	28.20	25.18	22.37	20.81

Figure 5: Average spot prices and forward prices in NSW, QLD, SA and VIC

4.2 Environmental value

The Commission relates the environmental value to *'the extent to which distributed generation contributes to the reduction of a particular environmental impact'*[49]. We assume that this refers to a reduction in the impacts of climate change in as the Commission has indicated that they expect the *'main environmental impact of relevance to this inquiry is avoided carbon emissions'*[50].

Renewable Energy Target

The Commissions initial view is that *'the environmental benefit of distributed generation from renewable sources may be sufficiently reflected in the payments available under the RET'*[51]. The Institute strongly disagrees with the Commissions initial view, and questions what evidence this view is based on.

It is not clear what evidence was used by the Commission, or how it was used to arrive at this position. Indeed the Commission specifically notes that *given the objectives of the RET, it is impossible to put a specific value on each objective* [52]. The Institute would welcome details on what evidence the Commission based this view on, particularly given that the environmental value is a key item in the terms of reference.

Under the Renewable Energy Target, eligible small-scale renewable energy system (<100kW) are issued with Small-scale Technology Certificates (STC) upfront. The number of STCs issued is determined by the electricity the renewable energy system is expected to produce over the deemed lifetime (10 or 15 years)[53]. While the Commission has pointed out that the clearing price for certificates is $40, these certificates are not representative of energy output (MWh) over the lifetime of a new system.

In the calculation of certificates, an average daily perfomance of approximately 3.25 kWh/KWp/day is assumed for Melbourne, which equates to a capacity factor of 13.53%. New systems in Melbourne can be expected to achieve average daily performances of 3.73-4.14 kWh/kWp/day [54] (15.54% - 17.25% capacity factor) and expected to produce power for approximately 25 years. Using these values, a new solar system would produce approximately twice as much energy as it receives certificates for under the SRES. At Victorian emissions intensity (and assuming all the value of the certificate was apportioned the the environmental value), the cost of abatement is $15.70 per tonne.

Phase out of the small-scale scheme

The Small-scale Renewable Energy Scheme (SRES) will begin to phase out from 2017[55], with the deemed lifetime decreasing annually to zero by the end of 2030 [56]. The value

[49] ESC, *Inquiry into the true value of distributed generation - Proposed Approach Paper*, page 4.
[50] Ibid., page 4.
[51] Ibid., page 3.
[52] Page 48
[53] Depending on Technology
[54] See APVI solar performace map
[55] CCA,RET Legislation
[56] See Table 4.2 in the Appendix for the phase out schedule

of abatement (as calculated above) will commensurately decrease from 2017. Even if the Commission maintains that the environmental value is currently reflected via payments through the RET, this is clearly a short term proposition for systems under 100kW in size. This is particularly relevant for many distributed technologies, most notably solar photovoltaic systems.

Social Cost of Carbon

We agree with the Commissions view that is possible to attribute a carbon emission reduction value to distributed generation by identifying the comparative emissions intensity of the generation and applying a carbon price. An appropriate carbon price to apply to determine this value is the Social Cost of Carbon.

The Social Cost of Carbon (SCC), a widely used methodology for valuation of the estimated damages associated with an incremental increase in carbon dioxide (or equivalent) emissions in a given year. In the United States, the Environmental Protection Authority and other federal agencies use the social cost of carbon to estimate the climate benefits of various regulations. The United States 'Interagency Working Group on Social Cost of Carbon' defines the Social Cost of Carbon as such[57]:

> *The purpose of the 'social cost of carbon' (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change*

Table 2 shows the most recent update (July 2015) of the SCC, converted to 2015 AUD as used by the U.S. EPA[58]. The working group uses a 3% discount rate as the central estimate, and the SCC value for the 95th percentile at a 3% percent discount represent the higher-than-expected impacts, *'from from temperature change further out in the tails of the SCC distribution'*.

A more recent Stanford study published in Nature Climate Change[59] suggest that current Social Cost of Carbon is $220 U.S. per tonnne for 2015, significantly higher that the value $37 (in 2007 dollar) used by EPA for 2015. Similarly, updated work by Stern[60] suggest optimal carbon prices are the range \$32-103/tCO_2 (2012 prices) in 2015, increasing in real terms to \$82-260/tCO_2 with in two decades to keep global mean temperature to within 1.5-2^{o}C above pre industrial levels. For scenarios limiting global temperatures increases to a maximum of

Table 2: Social Cost of CO_2, 2015-2050 (in 2015 Australia Dollars per metric ton CO_2)

	Discount Rate and Statistic			
Year	**5% Average**	**3% Average**	**2.5% Average**	**3% 95th percentile**
2015	$18	$58	$90	$169
2020	$19	$68	$100	$198
2025	$23	$74	$110	$222
2030	$26	$81	$118	$245
2035	$29	$89	$126	$271
2040	$34	$97	$135	$295
2045	$37	$103	$143	$317
2050	$42	$111	$153	$341

[57]Domestic Policy Council, "Technical Support Document".

[58]See the Table 3 in the Appendix for the values as publish in units of in 2007 Dollars per metric ton CO_2. Exchange rate used (as of 10 Feb 2016) was 0.71.

[59]Moore and Diaz, "Temperature impacts on economic growth warrant stringent mitigation policy".

[60]Dietz and Stern, "Endogenous Growth, Convexity of Damage and Climate Risk".

2°C Nordhaus[61] also estimates higher cost estimates the U.S figures. While there are broader debates about the potential for catastrophic damages under climate change, and appropriate discount rates and a large range in the literature the central estimate figures used by the EPA would appear to be on lower side.

Combined approaches: Health & Environment

There are a other estimates that consider the costs of *all* emissions together (for example SO_2, NO_x, $PM_{2.5}$ & carbon), which could also be used.

A recently developed economic valuation framework called the Social Cost of Atmospheric Release (SCAR) extends the Social Cost of Carbon (SCC) used previously for carbon dioxide to a broader range of pollutants and impacts to incorporate health impacts of air quality along with climate damages[62]. Illustrative calculations indicate environmental damages for US electricity generation are $140-340 per MWh for coal and $40-180 per MWh for gas.

This is broadly consistent with an other study on the Health and climate benefits of different energy-efficiency and renewable energy choices[63]. This study considered the monetized public health and climate benefits of four different illustrative energy efficiency and renewable energy installation scenario in six different locations the United States. This study considered the effects of displacing air pollutant emissions such as SO_2, NO_x, which affect concentrations fine particulate matter $PM_{2.5}$. See figure 6 for a summary of the results.

Alternative approach

An alternative price might be to consider what the carbon price would need to be avoid the 2 degree target (rather than explicity determining avoided costs. There are several studies that investigate the the carbon price required to meet the 2 degree target. A 2013 study published in Nature found that achieving IPCC 'success' (>66% chance of limiting warming to 2 degrees) would required a global carbon price of $60/tonne in 2015. Achieving the same "success" with action starting in 2020 would require a 2020 carbon price of $150/tonne[65].

Table 2 | Total benef ts from CO_2, NO_x, and SO_2 emissions reductions for each of four EE/ RE types in six locations, in 2012 US$ per MWh of generation.

	Wind	PV	DSM base	DSM peak
North-central Ohio	150	110	150	99
Chicago area	150	63	120	63
Virginia	91	120	130	44
Cincinnati area	170	150	150	72
Eastern Pennsylvania	81	81	95	14
Southern New Jersey	110	99	94	81

Figure 6: Total benefits from CO_2, NO_x, and SO_2 emissions in the U.S.[64]

[61] Nordhaus, "Estimates of the Social Cost of Carbon".
[62] Shindell, "The social cost of atmospheric release".
[63] Buonocore et al., "Health and climate benefits of different energy-efficiency and renewable energy choices".
[64] Buonocore et al., "Health and climate benefits of different energy-efficiency and renewable energy choices".
[65] Rogelj et al., "Probabilistic cost estimates for climate change mitigation".

The market value of carbon?

Market based prices for carbon exist in several jurisdictions around the world. There are now several emissions trading scheme (ETS) around the world. The largest, the European ETS currently trading below $8 AUD , and second largest, the Californian cap and trade scheme at $18 AUD [66].

In Australian, the Federal Government currently provides incentives to reduce carbon emissions via the 'Emissions Reduction Fund'. Through the scheme, contracts are awarded to organisations and individuals to reduce emissions through a competitive auction. The first auction in April 2015 delivered an average price per tonne of abatement of $13.95, and the next auction (November 2015) delivered an average price of $12.25 per tonne of abatement.

It must be stressed that the external costs of greenhouse gas emissions from fossil-fuel combustion are not completely internalized and reflected in these prices. From a strict economic perspective, an efficient carbon price would be set equal to the marginal damage of one ton of CO_2[67].

In Australia both Emissions Reduction Fund and the previous carbon pricing package[68] emerged from a complex political negation process[69]. The price is a political compromise and therefore below what would be considered 'cost reflective'. The external costs are not fully internalized, and the price is thus not set at efficient level. While such market based carbon pricing may result in *'greenhouse gas reductions [being] reflected in the market determined wholesale electricity price'*[70], as the VCEC inquiry argued, this does not mean cost are *completely* reflected.

As noted in the EU, it is questionable whether it would be politically feasible to implementing efficient prices due to the potential burden for participating industry sectors[71]. However, it is beyond the Terms of Reference of this inquiry to consider political feasibility, and inappropriate to use politically negotiated prices to determine carbon and environmental *value* that are not truly cost-reflective.

[66] as of Wednesday 10th February 2016

[67] Lehmann and Gawel, "Why should support schemes for renewable electricity complement the EU emissions trading scheme?", page 600.

[68] Prior to this Emission Reduction Fund, the Commonwealth's Clean Energy Future legislation introduced an ETS , with fixed carbon price of $23 from 1 July 2012, (increasing with inflation and moving to a market-determined price after three years)

[69] This is also true of the EU ETS and other. For further discussion see Lehmann and Gawel, "Why should support schemes for renewable electricity complement the EU emissions trading scheme?"

[70] Victoria and Victorian Competition and Efficiency Commission, *Power from the people*, page 61.

[71] Lehmann and Gawel, "Why should support schemes for renewable electricity complement the EU emissions trading scheme?", page 600.

References

2009 Victorian Bushfires Royal Commission, ed. *Final report.* Melbourne: Parliament of Victoria, 2009 Victorian Bushfires Royal Commission, 2010. 5 pp. ISBN: 978-0-9807408-2-0 978-0-9807408-3-7 978-0-9807408-4-4 978-0-9807408-5-1 978-0-9807408-1-3.

Anderson, E. J., X. Hu, and D. Winchester. "Forward contracts in electricity markets: The Australian experience". In: *Energy Policy* 35.5 (2007), pp. 3089–3103.

Australian Energy Regulator. *State of the energy market 2015.* Melbourne: Australian Energy Regulator, 2015. ISBN: 978 1 922145 67 3.

Biegler, T. *The hidden costs of electricity: externalities of power generation in Australia.* ATSE, 2009.

Buonocore, Jonathan J. et al. "Health and climate benefits of different energy-efficiency and renewable energy choices". In: *Nature Climate Change* (Aug. 31, 2015). ISSN: 1758-678X, 1758-6798. DOI: 10.1038/nclimate2771.

Caldecott, Ben et al. *Stranded Assets and Thermal Coal: An analysis of environment-related risk exposure.* Tech. rep. University of Oxford's Smith School of Enterprise and the Environment, Jan. 2016.

COAG. *Best Practice Regulation - A guide to got Ministerial councils and national standard setting bodies.* Council of Australian Governments, Oct. 2007.

Dietz, Simon and Nicholas Stern. "Endogenous Growth, Convexity of Damage and Climate Risk: How Nordhaus' Framework Supports Deep Cuts in Carbon Emissions". en. In: *The Economic Journal* 125.583 (Mar. 2015), pp. 574–620. ISSN: 00130133. DOI: 10.1111/ecoj.12188.

Domestic Policy Council. "Technical Support Document:-Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis-Under Executive Order 12866". PhD thesis. Environmental Protection Agency, 2013.

Edenhofer, Ottmar et al. "Closing the emission price gap". en. In: *Global Environmental Change* 31 (Mar. 2015), pp. 132–143. ISSN: 09593780. DOI: 10.1016/j.gloenvcha.2015.01.003.

Energy Safe Victoria. *Powerline Bushfire Safety Taskforce - Final Report.* Melbourne, Sept. 30, 2011.

ESC. *Inquiry into the true value of distributed generation - Proposed Approach Paper.* Tech. rep. Melbourne: Essential Services Commission, Dec. 2015.

Garnaut, Ross. *Australia After Paris: Will we use our potential to be the energy superpower of the low-carbon world?* Public lecture. Perth, Australia, Jan. 2016.

Lehmann, Paul and Erik Gawel. "Why should support schemes for renewable electricity complement the EU emissions trading scheme?" In: *Energy Policy* 52 (Jan. 2013), pp. 597–607. ISSN: 03014215. DOI: 10.1016/j.enpol.2012.10.018.

McConnell, Dylan. "Capacity value assessment of distributed solar in the NEM". Presentation. Asia Pacific Solar Research Conference. Brisbane, Australia, Dec. 8, 2015.

McConnell, Dylan et al. "Retrospective modeling of the merit-order effect on wholesale electricity prices from distributed photovoltaic generation in the Australian National Electricity Market". In: *Energy Policy* (Mar. 2013). ISSN: 03014215. DOI: 10.1016/j.enpol.2013.01.052.

Moore, Frances C. and Delavane B. Diaz. "Temperature impacts on economic growth warrant stringent mitigation policy". In: *Nature Climate Change* 5.2 (Jan. 2015), pp. 127–131. ISSN: 1758-678X, 1758-6798. DOI: 10.1038/nclimate2481.

Nordhaus, William. "Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches". In: *Journal of the Association of Environmental and Resource Economists* 1.1 (Mar. 2014), pp. 273–312. ISSN: 2333-5955, 2333-5963. DOI: 10.1086/676035.

Productivity Commission. *Electricity Network Regulatory Frameworks: Productivity Commission Inquiry Report, Volume 1.* Vol. 1. 2 vols. No. 62. Canberra: Productivity Commission, Apr. 9, 2013. ISBN: 978-1-74037-435-4.

Productivity Commission. *Electricity Network Regulatory Frameworks: Productivity Commission Inquiry Report, Volume 2*. Vol. 2. 2 vols. No. 62. Canberra: Productivity Commission, Apr. 9, 2013. ISBN: 978-1-74037-436-7.

Robin Scott MP, Minister for Finance. *Amendments to the Terms of Reference for the inquiry into the true value of distributed generation to Victorian consumers*. Letter. Dec. 24, 2015.

Rogelj, Joeri et al. "Probabilistic cost estimates for climate change mitigation". en. In: *Nature* 493.7430 (Jan. 2013), pp. 79–83. ISSN: 0028-0836. DOI: 10.1038/nature11787.

Shindell, Drew T. "The social cost of atmospheric release". en. In: *Climatic Change* 130.2 (May 2015), pp. 313–326. ISSN: 0165-0009, 1573-1480. DOI: 10.1007/s10584-015-1343-0.

The Parliament of South Australia. *National Electricity (South Australia) Act 1996*. Dec. 13, 1998.

The Parliament of Victoria. *Essential Services Commission Act 2001*. Tech. rep. No. 62 of 2001. Jan. 1, 2002, p. 75.

Victoria and Victorian Competition and Efficiency Commission. *Power from the people: inquiry into distributed generation final report July 2012*. Melbourne: VCEC, 2012. ISBN: 978-1-922045-14-0 1-922045-14-4 978-1-922045-17-1 1-922045-17-9.

Ward, Jordan and Mick Power. *Cleaning up Victoria's Power Sector: the full social cost of Hazelwood power station*. Tech. rep. Harvard University: Harvard Kennedy School of Government, 2015.

Watts, Nick et al. "Health and climate change: policy responses to protect public health". In: *The Lancet* 386.10006 (2015), pp. 1861–1914.

West, J. Jason et al. "Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health". In: *Nature Climate Change* 3.10 (Sept. 22, 2013), pp. 885–889. ISSN: 1758-678X, 1758-6798. DOI: 10.1038/nclimate2009.

Appendix

Table 3: Social Cost of CO_2, 2015-2050 (in 2007 U.S. Dollars per metric ton CO_2)

	Discount Rate and Statistic			
Year	**5% Average**	**3% Average**	**2.5% Average**	**3% 95th percentile**
2015	$11	$36	$56	$105
2020	$12	$42	$62	$123
2025	$14	$46	$68	$138
2030	$16	$50	$73	$152
2035	$18	$55	$78	$168
2040	$21	$60	$84	$183
2045	$23	$64	$89	$197
2050	$26	$69	$95	$212

Table 4: Phase out of the deeming period under the Small-scale Renewable Energy Scheme

Installation date	**The deemed life of the system** [72]
Up to and including 31 December 2016	15 years
From 1 January 2017	14 years
From 1 January 2018	13 years
From 1 January 2019	12 years
From 1 January 2020	11 years
From 1 January 2021	10 years
From 1 January 2022	9 years
From 1 January 2023	8 years
From 1 January 2024	7 years
From 1 January 2025	6 years
From 1 January 2026	5 years
From 1 January 2027	4 years
From 1 January 2028	3 years
From 1 January 2029	2 years
From 1 January 2030	1 year
After 31 December 2030	Nil

[72] The specified maximum number of that certificates can be created