Singapore's long-term low emissions strategy
National Climate Change Secretariat

2019

A response to the public consultation on the 2050 strategy document

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1 Introduction

The work the NCCS is doing through this consultation paper is very important and will hopefully inform the long-term emissions strategy for the country. Starting of course with a potential increase in ambition with regard to the country's Nationally Determined Contribution. Singapore does have limitations as a result of its size and relative reliance on things imported from other countries, but this traditionally hasn't stopped the country from performing well in excess of perceived capacity. Action on climate change is another area in which Singapore may be able to act strongly and lead by example. Particularly as there is significant exposure to physical risk for the country. In many ways, it is incumbent on Singapore to provide strong action in this area to provide weight to the argument that other countries have to do more.

engeco welcomes the opportunity to contribute to this consultation process and looks forward to further engaging with the NCCS in future as the long-term emissions reduction strategy is executed.

2 About engeco

engeco is a Singapore based consulting firm that specializes in climate change. We help companies understand their exposure to climate change risk and develop and implement climate change strategy. With a core technical knowledge in industrial settings, and a deep understanding of impacts of climate change, engeco consultants are well placed to help businesses and Governments understand this very complex area and assist with development of abatement options and broader climate change strategy.

engeco's technical director, Marc Allen, is a chemical engineer with 20 years' experience since graduating. He has worked in mining and resources, oil and gas and spent significant time working in the hydrogen industry manufacturing and transporting hydrogen in Australia. For the last 12 years, he has specialized in climate change and sustainability and applies engineering knowledge to calculate value chain emissions for corporations and analyze their exposure to climate change risk as a result of those emissions. He also helps with abatement options and other actions to reduce this risk exposure to acceptable levels.

3 General comments on the paper

Climate change presents a serious threat to Singapore both economically and physically. To avoid the worst impacts of climate change, significant decarbonization efforts need to be pursued by all countries. In general, to meet the Paris Agreement targets of well below 2 degrees C by the year 2100, emissions globally must peak as soon as possible and reach net zero just after the middle of the century – with emissions being drawn down out of the atmosphere after than point (net-negative emissions).

The size and scale of this challenge cannot be underestimated and it's commendable that Singapore is preparing this long-term emissions reduction strategy and consulting widely on its effectiveness. The purpose of this paper and the long-term decarbonization strategy should be to inform Singapore's future emissions reduction targets under the Paris Agreement (their Nationally Determined Contribution). To assist with meeting global goals all targets by all countries should be increased in ambition, and Singapore's is no exception. The fight against climate change is not one that can be won without all countries, all businesses and all people pulling in the same direction. All countries should be encouraged to set targets in line with achieving net-zero emissions in the middle of the century to avoid the worst risks. Even now, there will be a mix of both adaptation and mitigation activities as a certain amount of climate change is already "locked in". To continue along the decarbonization pathway that represents the currently pledged nationally determined contributions will lock in temperatures well in excess of the Paris Agreement goals and this will prove very difficult to adapt to – particularly after 2100.

In general, this consultation paper is very good at discussing specific technologies or opportunities for the country – and this is an important discussion. What is important now is how to structure policy frameworks to achieve these goals. What can we do now to promote the use of technologies such as renewable energy, electric vehicles, hydrogen and carbon capture, utilization and storage and changing business models such as the move to a circular economy in the future as they are all vital to global success. The carbon price is a key policy lever in action on climate change but needs to be set at a point at which the required systemic change can occur. In the absence of that, supporting policies should be implemented to drive change towards the high cost decarbonization options. This could involve research grants and subsidies where appropriate or complementary policies such as renewable energy targets.

Singapore is well placed to take advantage of the global transition to a net-zero emissions, circular economy. The country already has good standards and governance structures, particularly in the finance industry, which can be adapted for use in the new, sustainable future. As with every transition however, it is important to ensure that the transition is just and that all parts of society benefit.

One of the most important parts of the transition, from a business point of view, is developing an understanding of how climate change risk impacts the value chain of that business. The framework developed by the Task Force on Climate-related Financial Disclosures provides a good way for businesses to analyse their exposure and develop strategies to mitigate that risk. With that in mind, there may be a role for Government in knowledge sharing with regard to the importance of such a framework and highlighting climate risk as a concept. Making TCFD style disclosure mandatory may not be in the best interests of good disclosure in the short term but

could be a consideration in future years if the quality or quantity of disclosure from the business world proves to be inadequate.

It is good that Singapore takes the issue of climate change seriously and is developing a policy framework to suit – more can, and must, be done. As the Government has made clear in recent messaging, the country faces a serious risk from climate change and the impact on low lying island states. Action must accelerate quickly – not just by Singapore but by all nations to have a chance of meeting the overall aims of the Paris Agreement. The results of this consultation and the subsequent policies that will be put in place in Singapore should be used to inform Singapore's new emissions reduction target in time for next year's Conference of Parties in Glasgow.

4 Specific responses to sections

4.1 ENERGY EFFICIENCY

The ECA has been, and continues to be, an effective policy response to address knowledge gaps in energy efficiency within industry and large energy users. Providing a regulatory requirement to have a certified energy manager and to carry out assessments of energy efficiency opportunities arms business with the tools and knowledge to improve energy use. There still remains an issue that not all viable opportunities are implemented. This could be addressed through providing a requirement to document and submit high level summaries of potential opportunities to the NEA and document reasons for not implementing projects under a threshold payback level (e.g., 3 years). This information can be collated and released as an anonymous set of data by the NEA to provide guidance for other companies in their energy efficiency assessment process.

In general, there is only a limited amount of energy efficiency activity that can be completed on existing facilities as the design of the facility is locked in and changes to design are often costly. As a result, the energy efficiency opportunity process could be extended to include new facilities or major expansions. This is because the greatest opportunity to influence long term energy use is through making appropriate design decisions. The framework could be such that new facilities or major expansions with energy consumption above the participation threshold would be required to complete energy efficiency opportunity assessments during the design phase and demonstrate that energy consumption through the operational phase of the facility is as low as reasonably practicable. Identified energy efficiency opportunities that show a positive net present value compared to a baseline or original design should be implemented or the reasons for not implementing explained.

The setting of minimum energy performance standards is critical and a good lever to ensure efficient equipment is being purchased where possible. It is appropriate also to set these performance standards for both household and industrial equipment. From a household point of view, there should be a prioritization in setting these standards starting from large energy consumers such as refrigerators and air conditioners down to lower energy consumers. There could also be programs put in place to encourage households to switch to efficient appliances such as induction cooktops and heat pump water heaters rather than their pure electric or natural gas/town gas fired appliances.

There is still a role to play for education programs for both businesses and households. As previously mentioned, there is some potential for anonymous knowledge sharing where details of energy savings identified by different businesses could be published for others to explore. In addition, guidance and training for how to conduct energy efficiency assessments, typical opportunities and developing business cases could also be of benefit. For households, similar education programs on saving household energy and education on MEPS and MELS programs should show results. There may even be an opportunity for workshops and/or household energy audits to provide households with practical measures to reduce energy use.

Specific responses to sections

4.2 CARBON PRICING

Carbon pricing remains as the primary lever for countries to achieve emissions reduction, the current carbon pricing system in Singapore, despite potentially not being as economically efficient as an emissions trading scheme, appears to be fit for purpose. It will act to drive change but still has the potential for flexible compliance mechanisms through the use of the fixed price, credit based framework. Allowing the use of international permits is an improvement that should be explored in coming years to enable liable entities to pursue least cost abatement and least cost compliance – wherever that abatement may occur. A further enhancement to the system could be a framework whereby companies can generate credits from implementing abatement projects within the country. Care must be taken around the accounting of these credits to ensure companies do not get a double benefit (e.g., through reducing their own exposure to the carbon price liability and also generating credits that they then use) but this can be managed through an increase in the net emissions for a liable entity facility that also generates credits.

The carbon price set by the Government is key to achieving decarbonization goals for the country. The price must be set a point consistent with relatively rapid decarbonization to achieve the long-term goal of net zero emissions soon after 2050. The current price of $5/tonne of CO_2-e is, in general, too low to encourage the level of decarbonization required. The International Energy Agency, in their Sustainable Development Scenario – which is consistent with the aims of the Paris Agreement, suggests that carbon prices are at the following levels to support the level of decarbonization required.

Carbon Prices - IEA Sustainable Development Scenario

AREA	2025 CARBON PRICE	2040 CARBON PRICE
Advanced economies	$63 USD/tonne CO_2-e	$140 USD/tonne CO_2-e
Developing economies	$43 USD/tonne CO_2-e	$125 USD/tonne CO_2-e

Reference – IEA World Energy Outlook 2018

Clearly there is a disconnect between the current level of carbon price and that modelled by the IEA in their Sustainable Development Scenario. The current carbon price does represent the trade off between the desires of business and the requirements to decarbonize and, globally, a decarbonization pathway consistent with the Paris Agreement is not yet being achieved but it is clear that the level of carbon price will need to be increased substantially to achieve the Paris Agreement goals. This is starting to be analyzed by corporations as part of climate risk analysis and scenario planning in line with the Paris Agreement scenario. Companies completing this analysis are aware of the potential financial impact of high carbon price scenarios on their business.

In addition, many companies are applying internal carbon prices to stress test their potential investments and make informed decisions. In 2017, nearly 1,400 companies globally reported to CDP that they either currently use (607 companies) or intend to use an internal carbon price within the next two years (782 companies). In Singapore, CDP reports that 8 companies disclosed

that they use or intend to use an internal carbon price. This indicates that companies are actively preparing for a world in which carbon prices are widespread and are making sure that future investments are not being exposed to an unacceptable risk. In general, internal carbon prices being employed by many companies are greater than explicit carbon prices being set by Governments. This is consistent with stress testing investments and performance against future scenarios of climate change action – including a Paris Agreement scenario.

With regard to emissions intensive trade exposed industries, until carbon pricing is applied consistently in all markets, there is a requirement to ensure that emissions intensive trade exposed industries are not unfairly exposed compared to competitors. This could be in the form of free permits or compensation for a portion of the total liability exposure. Such arrangements should however take into account the percentage of the export market that is currently exposed to a carbon price of some description and the effective carbon price in place. Consideration should also be given to the other comparative advantages investment in Singapore has over other jurisdictions i.e., there may be a carbon price in Singapore but other favorable arrangements such as company tax may still mean that investment in Singapore is more attractive on balance. The overarching aim of any climate policy is to ensure decarbonization goals are met so this should also be a consideration when determining support for emissions intensive trade exposed industries.

When determining whether a company merely pays the carbon price or implements an abatement project, there are a number of factors that are taken into account. One of the primary decision points however is whether it is cheaper to pay the carbon price or to implement an abatement project. If the carbon price is the cheaper option on a net present value basis – taking into account likely escalations in the price point, then companies will tend to pay the carbon price. When looking to promote particular technologies or abatement options then there may be an opportunity for complementary policy if the level of carbon price is not high enough to drive this change. This could be things like renewable energy targets or other regulations or mandates, potentially with support/subsidy from the Government – depending on the technology. This is an opportunity to bolster the main lever of the carbon price to assist with achieving decarbonization outcomes.

As a company, engeco is very familiar with all types of voluntary and compliance-based offsets and credits on the market. From Clean Development Mechanism permits, Australian Carbon Credit Units and EU Allowances to the voluntary permits available through the Gold Standard, Verra and others, engeco advises clients on the best way to achieve emissions reductions, which may sometimes involve the use of offsets. There could be merit in allowing the use of certain offsets, e.g., those that have robust verification mechanisms and meet certain criteria, in defined percentages to help companies meet their compliance obligations under the Singapore carbon pricing scheme. This will allow some flexibility in the way in which companies acquit their liability and is in line with the overarching concept of pursuing least cost abatement/emissions reductions. Care must be taken in the types and amounts of offsets allowed but this can be addressed through regulation.

4.3 POWER GENERATION

Singapore's work in deploying solar PV is commendable, as is the research that is ongoing with respect to floating solar PV and vertical solar. As costs of solar PV continue to fall the attractiveness of this type of power generation will only increase. Incorporation of grid level

battery storage to smooth the intermittent nature of power generation with increasing solar penetration will be the next challenge. Treatment of the grid as a system and integrating different supply options, storage technology and demand management will be an important part of Singapore's energy future. Underlying this will be a trend of future increases in electrical demand, coming from increasing electrification of household and industrial appliances and electrification of the transport industry.

As pointed out in the consultation paper, there is a limit to the amount of solar PV that Singapore will be able to generate within its borders, largely as a result of land constraints. There is still remaining potential for installation of solar throughout the island, and this should be exploited as much as possible, but it is unlikely that the country will be able to meet 100% of electricity demand from local renewable energy. Especially when taking into account the requirement to install more than 100% of peak demand to allow for energy storage – and the fact that energy storage will need to be at least double the size of peak load to account for the typical capacity factor of solar PV. Singapore neither has the size/variation in cloud cover nor the diversity in renewable energy potential (e.g., wind, geothermal, tidal) to increase renewable penetration without significant energy storage.

The challenge to decarbonize the power generation system then falls to three main options:

- Zero carbon fuels in existing infrastructure
- Import of renewable power from other countries
- Carbon, capture and storage (or utilization)

Zero carbon fuels covers the use of imported or domestically generated biogas or gasified biomass and burning the methane or syngas in the current combined cycle power plants or the use of hydrogen. Hydrogen will be discussed later in this document. With regard to biogas or gasified biomass, the supply chain will be important – e.g., obtaining long term supplies relatively close to Singapore to minimize shipping costs and impact. Ensuring that the source of biomass/biogas doesn't have an adverse environmental impact would also be very important.

Importing of renewable power from other countries could show significant promise as a method of decarbonizing the country's energy supply. Ideally, the concept of an ASEAN grid with significant renewable energy penetration is most beneficial to take advantage of diversity of energy supply sources over a relatively large geography – which should increase penetration or renewable energy – and the proximity of the various ASEAN member states has an advantage with regard to minimizing transmission losses when compared to importing power from countries like Australia. An ASEAN centred grid would also benefit greatly from using things such as geothermal energy from Indonesia, which can have a much higher capacity factor before energy storage. With energy storage, an ASEAN centred grid would also allow for relatively cost effective, high volume energy storage such as pumped hydro to be used. Battery systems and other energy storage could be dispersed throughout the rest of the grid and used as grid support. Conceptually this grid has potential through the region though it is a challenge politically and does carry an element of risk. Import of energy via long submarine cables from countries like Australia (e.g., the Sun Cable or Asian Renewable Energy Hub projects) is potentially lower sovereign risk but will be high cost, which means it will be high energy cost, and the losses across that distance will be significant – even for high voltage DC cable.

Carbon, capture, utilization and storage is a way to decarbonize the existing natural gas fired system. Although this could be employed, other options may prove to be cheaper in the long run. This is detailed further in the next section of this document.

4.4 LOW CARBON TECHNOLOGIES

4.4.1 Electric vehicles

Electric vehicles are a key part of a decarbonized future and Singapore, because of its relative size, has the potential for rapid uptake and large-scale penetration of electric vehicles. Concerns such as range anxiety are less of an issue in Singapore than in other countries. Electrification, particularly in personal transportation, is likely to happen in spite of particular policy positions as the majority of car manufacturers are committing to electric vehicles and prices are reducing rapidly as global manufacturing capacity continues to ramp up. The inflection point, where electric vehicles are lower upfront cost than the equivalent internal combustion vehicle is approaching and at that time, relatively rapid uptake is expected. Singapore will merely respond to the cars available in the market so consumers may favour electric vehicles in the not too distant future. This will however require some policy direction and potentially Government support for charging infrastructure. Particularly in Housing Development Board properties and more widely across the island. If the inevitability of electric vehicles is assumed, then ensuring the infrastructure is available for consumers is key.

One downside of the increase in electric vehicle penetration from a Government point of view is a reduction in fuel excise collected. This could however be addressed with road use charges – potentially using the proposed ERP system that is linked to GPS and has the capability to monitor road usage.

The aim of a 'car-lite' Singapore is commendable and supports climate change goals – even after an increase in electric vehicle penetration. The Singapore Government should continue to promote the use of public transport and pedestrian transport as a policy lever acting to achieving climate related goals and increase the livability of the country. There could be an opportunity to decrease the emissions intensity of public transport by moving away from diesel powered buses, which cause both GHG and particulate emissions, to cleaner options such as natural gas, battery electric and potentially even hydrogen fuel cells.

Another potential outcome, particularly in the area of personal transportation, is the concept that the personal transport system of the future will be clean, on-demand and autonomous. This is one hypothesis that explores the idea that personal vehicle ownership will drop significantly as a result of autonomous on-demand transport. In this future, the utilization of vehicles increases but the total number of vehicles on the road decreases – which may then allow for a more pedestrian and bicycle friendly city. An increase in the quality and amount of bicycle infrastructure could also be considered as the personal transportation system changes in coming years.

The move to zero carbon transportation is critical in coming years and it is important that Singapore provides a supportive policy environment and allows for the infrastructure to make this move. While there are a number of zero carbon transport options available and ongoing research in this area, it does seem that battery electric vehicles will be commonplace for personal vehicles with hydrogen and advanced biofuels in other areas.

4.4.2 Carbon capture, utilization and storage

It is acknowledged that there is work underway to explore the viability of carbon capture, utilization and storage (CCUS) in Singapore. CCUS is an important part of the low carbon future, particularly in areas that are currently difficult to decarbonize fully such as steel and cement manufacture. The key barrier to widespread adoption of CCUS in the short term is cost. The breakeven carbon price required to make a CCS project worthwhile (that is, the carbon price required to give a net present value of zero) is well in excess of the current carbon price, and greater than most carbon prices in place globally. It's not uncommon for the breakeven carbon price for CCS on a power generation plant to be over $100 USD/tonne.

The utilization part of CCUS is being researched by many different ventures but is yet to be commercial, with the exception of enhanced oil recovery. In addition, the amount of carbon available as CO_2, if turned into other products, is so great that existing markets are dwarfed by the potential production via the CO_2 utilization route. For example, global methanol production is just over 100 million tonnes per year, which is equivalent to capture and use of 137 million tonnes per year of CO_2 – quite a small percentage of total CO_2 generated globally.

If CCUS was to be pursued by Singapore as a material abatement option for the country, then policy would be required to encourage investment in this area. This could involve co-investment in potential projects, de-risking projects for proponents and maybe even operation and investment in storage facilities or utilization processes to act as a hub for emitters to provide captured CO_2 into. CCUS shouldn't be explored in isolation however – it is just one option for decarbonization available to Singapore and should be examined as a potential solution within the suite of solutions. That is, the abatement potential and cost of CCUS must be examined in conjunction with solutions such as increased use of hydrogen in the economy, expansion of local and imported renewable energy, use of biofuels and even the generation and use of offset projects internationally.

4.4.3 Hydrogen

Hydrogen, like CCUS, will play a role in the future low carbon economy – it is also the subject of intense study by a number of Governments, including Singapore. The final role that hydrogen plays in global economy is still being debated but it is likely that hydrogen's place will be as an industrial reagent, as an industrial heat source instead of natural gas and potentially in the power industry – either generation or grid level, high capacity storage. Hydrogen's role in transport may be limited to large users that require high availability such as shipping, aviation and long-range road and rail. Light vehicles, personal transport and last mile transport are potentially likely to be dominated by battery electric rather than hydrogen fuel cell.

There are a number of technical and economic barriers to expanding the use of hydrogen in the economy. Hydrogen in its pure state presents a challenge for transportation given its very low density. It either needs to be very high pressure or very low temperature to achieve transport in commercial volumes. This then presents materials of construction issues, which can be solved but all act to increase costs. Options are being explored globally with respect to using different hydrogen carriers such as ammonia or metal hydrides, but these act to reduce overall round trip efficiency as it then takes energy to release the hydrogen on the consumption side. These technologies do show merit though.

From a financial point of view, hydrogen is currently not competitive with alternatives. For green or renewable hydrogen manufactured via electrolysis from renewable energy, the cost of hydrogen for a solar power cost of $50/MWh – assuming all other things are free (electrolyzer, compression, storage and transport) is about $15/GJ. Given spot LNG is closer to $5/GJ, the carbon price needed to support this change in energy carrier – in the absence of complementary policy – is about $200 t/$CO_2$-e.

The use of hydrogen in the economy will have to come eventually, out of necessity to decarbonize certain parts of industry that are otherwise difficult. It is a good step that Singapore is spending time to understand various hydrogen supply chains so that it can be prepared. There may also be opportunities for the country to leverage off this understanding and sell technology to the world in future. Given the unfavorable economics currently, there is an opportunity for supportive complementary policy to try to increase the use of hydrogen in the economy. This could include development of standards and guidance, support or subsidies for R&D and other policy levers. There are benefits to being an early adopter for hydrogen and helping to strengthen global supply chains. The important thing to consider now is to maintain optionality into the future and not lock into a particular supply chain too early. The main use of hydrogen in Singapore is likely to be within industry as a replacement for natural gas and in the power generation industry, given Singapore's relatively low ability to greatly increase renewable energy penetration locally. Renewable hydrogen supply from countries with excess renewable energy should be explored in comparison to direct import of electricity from those countries.

4.5 COLLECTIVE ACTION

Individual actions are important and together may add up to larger action. There is however a limit to what individuals can do. The scale and speed of change required is such that systemic change is also required. For example, individuals can change light globes and reduce household energy use but the greatest change is possible when decarbonizing the energy system – which individuals have little ability to control save through demanding change and applying social license pressure.

4.6 GREEN GROWTH OPPORTUNITIES

There are a number of areas where Singapore can capitalize on green growth opportunities that build on the country's strengths and will contribute to continued success of the country.

Sustainable finance – Singapore is one of the financial centres of the world and there remains an opportunity to take advantage of the shift in financial markets towards sustainable investments. Singapore can continue to encourage sustainable investments and the development of financial vehicles and green bonds through supportive policy frameworks and things like the MAS green bond grant scheme to reduce the barriers to entry for proponents.

Trading – Singapore is already a trading hub for many different commodities. With this stong history, there is an opportunity to build on this and become a trading hub for carbon abatement. There is a regional advantage that Singapore has in this area also as many carbon abatement opportunities and projects around reforestation and avoided deforestation will occur in the region in coming years. There is potentially a role for Government in supplying a supportive policy environment to allow the market to act efficiently.

Specific responses to sections

Technology transfer – Singapore has a growth opportunity in the area of R&D, leading to technology transfer to other countries. Examples of this are things like the research the country is doing in the areas of floating solar and vertical solar. Future examples could be in hydrogen supply chains and use cases. Tapping on both the research capabilities of Singapore Universities and the robust entrepreneurial and tech-based startup industry could yield many opportunities for commercialization and sale of technology outcomes to the world.

Circular economy – the transformation of the economy to a circular economy is crucial to action on climate change and is seen as a key solution to some of the issues that have contributed to climate change in the first place (e.g., responsible consumption and production). Singapore is already doing some work in this area but there is a clear opportunity to scale up technical solutions and business models to support the transformation of the economy to a circular economy. Significant economic benefit is in these areas and Government's role is to provide knowledge and guidance – and a supportive ecosystem to allow these solutions to be deployed. It is important to note also that the move to a circular economy is more than just reducing waste, it's a transformation of products and business models to allow for more reuse, remanufacture and repair – long before recycling and waste reduction. Supporting elements of the sharing economy also feeds into this economic transformation.

In the transformation of the economy to a net-zero emissions economy, there will be sectors that are winners and those that are losers. The important thing from a Government point of view is that this transition is a just transition and that all parts of society are given a chance to thrive through this transition. This may include retraining and redeploying of people into other, "green" industries that are poised to be successful in the transformation. The Government should be considering these outcomes in their scenario planning and preparing for this economic transformation.

Finally, the Singapore Government should be using a scenario based, and risk based, framework for analysis of the future impacts of climate change – from both a transition and a physical point of view. Applying the TCFD style framework to inform both risks and opportunities could be incredibly beneficial when planning for the future.

Contact Information

MARC ALLEN
TECHNICAL DIRECTOR

Marc.Allen@engeco.com.au

Company Information

engeco Pte Ltd
Found8 – 1 North Bridge Road, High Street Centre #08-08, Singapore 170904
Tel +65 9107 8035
www.engeco.com.au