Renewable Hydrogen Target – stakeholder feedback template

Submission from [Carbon Transition Pathways]

This template has been developed to enable stakeholders to provide feedback on the questions posed in the Renewable Hydrogen Target consultation paper.

Energy Policy WA encourage stakeholders to use this template. If you wish to provide additional feedback outside the template, wherever possible please reference the relevant question/section to which your feedback relates.

No.	Question	Feedback
Renewable Hydrogen Target for electricity generation		
1	What are some examples of an objective or objectives that could be used to assess the benefits, costs and impacts of a Renewable Hydrogen Target for electricity generation?	No further objectives identified. Our observations however, prior to addressing key objectives, are that there is a fundamental issue with using renewable hydrogen for the purpose of electricity generation. By definition, "renewable" hydrogen is produced from renewable electricity, therefore, renewable hydrogen should be considered as a "storage" mechanism for renewable energy rather than a fuel in its own right. When considered in this way, it becomes intuitively clear that it does NOT make sense to take renewable electricity, make hydrogen and then burn the hydrogen to once again create electricity. In effect, you lose up to 80% of the generated power in the process. This, in itself, indicates that renewable hydrogen used to create electricity will destroy significant capital for no incremental value. Having clarified this point, CarbonTP is pleased to provide its thoughts on the existing objectives as per below: **Industry development –** A renewable hydrogen target for electricity generation would generate demand for hydrogen but at a prohibitive and unnecessary cost to consumers. Data provided indicates a cost of $6.60/kg = $55/GJ (LHV) without storage or

No.	Question	Feedback
		shipping and at a WACC of 7%. The cost of storage and shipping should not be underestimated as this will be significant given the issues with handling hydrogen. Assuming 35% efficiency for an OCGT generator this equates to a minimum electricity price of 55 x 3.6(GJ/MWh) / 0.35 (GTG efficiency) =$566/MWh (fuel cost only). With new renewables delivering an LCOE of ~$50/MWh, it implies you could afford to overbuild renewables with >90% curtailment for the same delivered electricity cost. Overbuilding 10x renewable capacity would permit WA to transition to very high percentages of renewables in the grid with significant low-cost excess capacity helping stimulate low carbon industry and jobs. **Decarbonisation of the grid –** CarbonTP's assessment is that use of renewable hydrogen for power generation will have minimal impact on decarbonising of the grid. In blending the hydrogen with gas, one will effectively be directly backing out gas fired electricity generation. OCGT generators typically have an emissions intensity of ~0.55tCO_2/MWh. At 10% of total SWIS generation capacity hydrogen would account for 18TWh x 10% = 1.8TWh annually. The associated emissions reduction would therefore be 1,800,000MWh x 0.55 = 990kt of CO_2. The cost of this reduction would be [55-6.2] differential between gas price and hydrogen price per GJ(LHV)) x 3.6 (GJ/MWh) / 0.35 (GTG efficiency) / 0.55 (tonnes of carbon saved per MWh) = ~$910/tonne and, in reality, much higher as hydrogen transport and storage costs have not been included. Given this cost, it appears that any alternative decarbonisation option is likely to be at a substantially lower cost, including deploying CCS at existing coal/gas plants which is estimated to be between $100-$300 per tonne CO_2 abated. **Grid reliability and stability –** This will have negligible, if any, impact on grid reliability and stability. There is no reason to believe hydrogen-based gas turbines will be any more reliable or

No.	Question	Feedback
		operationally flexible than methane-based turbines. In fact, there may be an argument to suggest hydrogen use in turbines designed for gas may reduce their reliability and uptime. **Reducing risk of fuel cost escalation –** CarbonTP's perspective is that comparing hydrogen with other fuels is fundamentally flawed. Hydrogen should be viewed as a storage mechanism for renewable energy as previously noted. Therefore, hydrogen should be compared with other alternatives to storage such as the cost of overbuilding renewables capacity coupled with grid scale batteries, vehicle to grid technology, demand response, pumped hydro, etc. When compared against these alternatives, hydrogen is likely to be significantly more expensive as illustrated above. **Decarbonisation of the West Australian Economy** – Current applications of hydrogen are a significant decarbonisation problem. For hydrogen to be viewed as a solution to decarbonisation, existing production of hydrogen should be addressed first. CSPB use >40,000 tonnes of hydrogen annually, made from natural gas to make ammonia emitting >400,000 tonnes of CO_2 in the process. Using renewable hydrogen capacity for electricity generation will only serve to delay decarbonisation of such applications and have a lower emissions reduction impact. Renewable energy can be better used directly to decarbonise power generation and make hydrogen for use in industry. • For example, 1GWh of renewable electricity used directly to replace coal fired generation will save ~900 tonnes of carbon emissions. (Coal fired power typically generates 0.9tCO2/MWh – 1000 x 0.9 = 900)) • 1GWh used to make hydrogen for use in ammonia manufacturing will save ~210 tonnes of carbon emissions (1GWh will make ~19 tonnes of hydrogen at

No.	Question	Feedback
		52MWh/tonne efficiency. Typical emissions from an SMR process are 11tCO2 per tonne hydrogen – 1000/52 x 11 = 211) • 1GWh used to make hydrogen for use in an OCGT will save only 120 tonnes of carbon emissions (Hydrogen contains 33.3MWh/t (LHV) and OCGT is 35% efficient and generates 0.55tCO2 per MWh – 19 x 33.3 x 0.35 x 0.55 = 122)
2	How might other uses of renewable hydrogen be accommodated under a Renewable Hydrogen Target certificate scheme? How might Government otherwise support and/or encourage other use cases for hydrogen?	The highest order uses of hydrogen are for decarbonising steel making and decarbonising ammonia manufacturing. These are no regrets moves that will have significant and positive impact on carbon emissions while also creating offtake, which is a key driver for the WA Government. Decarbonising steel making through hydrogen is nascent technology, particularly for the grade of iron ores produced in WA, however decarbonisation of ammonia manufacturing is a simple substitution of green or renewable hydrogen for grey hydrogen produced from natural gas without abatement. Where the objective of the WA Government is to stimulate the green hydrogen industry, it would likely be appropriate for it to mandate a percentage of green hydrogen be used in manufacturing processes requiring hydrogen and stimulate a green steel industry. However this will add significant cost for the companies using green hydrogen which may need compensation of some kind including tax incentives or credits, similar to those put in place by the US Government under the recently legislated US Inflation Reduction Act.
Considering hydrogen		
3	What role do you believe renewable hydrogen can play in the decarbonisation of electricity generation? To what extent will a Renewable Hydrogen Target for electricity generation in the	Realistically, given renewable hydrogen is produced from renewable electricity, it is challenging to see any near term role that hydrogen can play in decarbonisation of electricity. It will be

No.	Question	Feedback
	SWIS assist in achieving the decarbonisation objectives of the State Government?	too expensive compared to alternatives and the inefficiency would lead to extensive capital destruction. For WA, a more cost-effective solution is likely to be overbuilding of renewables and long duration lower cost storage technologies, such as iron flow batteries, coupled with V2G, demand management and Gas Turbines burning methane for emergencies. In CarbonTP's view, electricity decarbonisation through hydrogen appears to be trying to solve the difficult last 10% of grid decarbonisation before addressing the much easier 70% of grid decarbonisation opportunities. It is likely that in decarbonising the 70% the solution to the last 10% will become more apparent. CarbonTP appreciates that burning hydrogen through WA government's existing electricity generation assets is something it can control, whereas many other applications fall within the purview of commercial entities, the WA government should not embark on a target that would potentially damage its credibility.
4	What role can the infrastructure associated with the production of renewable hydrogen (i.e. renewable electricity generation facilities, electrolysers, transport and storage infrastructure) play in the broader SWIS?	CarbonTP's view is that associated infrastructure will have limited to negligible role in the SWIS. Renewable generation facilities dedicated to hydrogen manufacturing would likely have excess capacity to maximise utilisation of the electrolyser, therefore this capacity may be usable in the grid although it will likely be available at the time all other renewables are at peak output. Electrolysers will not be helpful to soak up excess renewables for the above reason; at periods of peak renewables generation, they will already be running at full capacity. If an excess of electrolyser capacity were installed to be able to soak up excess renewables the reduced utilisation would make the resultant hydrogen extremely expensive. Hydrogen transport infrastructure is does not currently exist and the gas grid is unlikely to be suitable for long term use with

No.	Question	Feedback
		hydrogen notwithstanding claims from many countries that a certain percentage of blending with natural gas is possible. Hydrogen storage infrastructure does not exist on the SWIS and the only economically viable solution to storing meaningful quantities of hydrogen is man made salt caverns in suitable underground formations. If stored as ammonia, there is a significant processing cost penalty to consider.
Technical feasibility		
5	To the extent you are able please reflect on some of the technical issues, challenges and considerations in the utilisation of hydrogen in the generation of electricity. To what extent can these technical issues and challenges be overcome? How should this impact on the consideration of a Renewable Hydrogen Target for electricity generation in Western Australia?	The technical challenges and cost of storage and shipping should not be underestimated. How will the hydrogen be delivered? Current technology is to use a tube trailer which will transport approximately 1 tonne of hydrogen at high pressure. To pressurise the hydrogen will require ~15% of the useful embodied energy contained within the hydrogen and transporting it via road from point of manufacture to point of use will consume additional energy. A typical Prime mover with a single trailer consumes ~1.2kWh/km. Therefore if the source and point of consumption are 100km apart requiring a round trip of 200km the transport will consume the equivalent of 12kg of hydrogen or another ~1% of the delivered cargo. These steps will add significantly to the delivered cost. How will hydrogen be stored? Storage is currently achieved through use of high-pressure cylinders The US DOE has data on the cost of pressurised hydrogen storage with current costs being Est.US$14/kWh of capacity Converting to AUD this is equivalent to ~AU$22,000/MWh of storage capacity. If cycled once daily this would add ~$15/MWh of power generated and if cycled weekly it would add ~$100/MWh of power generated based on a 30 year life and 7% WACC. Our conclusion is that current distribution and storage technology is inadequate to support the utilisation of hydrogen in the

No.	Question	Feedback
		electricity grid and the construction of separate infrastructure such as dedicated hydrogen pipelines between producers and offtakers would also be prohibitively expensive.
Certificate schemes for Renewable Hydrogen Target for electricity generation in the SWIS		
6	Do you believe a renewable hydrogen electricity generation certificate-based scheme represents an efficient and effective means to deliver a Renewable Hydrogen Target for electricity generation in the SWIS? Please explain your answer.	As noted in previous responses, we believe that the use of hydrogen for electricity production has fundamental flaws, and therefore any schemes that encourage it will be a material destruction of taxpayer funds. The government should provide incentives to where hydrogen has its uses in manufacturing of hydrogen-based products in WA.
7	What are some other approaches which could be considered alongside a renewable hydrogen electricity generation certificate scheme that would provide a framework to deliver on the objectives or outcomes sought?	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
Liable entities		
8	Is the proposed approach of certification, deemed liability and certificate transfer an efficient and effective way to deliver on the intent of the Renewable Hydrogen Target for electricity generation? Are there alternative approaches which could better deliver on the objectives?	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
Exemptions		
9	What are the benefits, costs and impacts of an exemptions regime for a Renewable Hydrogen Target for electricity generation?	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
Non-renewable hydrogen		
Renewable fuels		
10	Should the Renewable Hydrogen Target for electricity generation consider alternative renewable fuels as eligible for the creation of Renewable Hydrogen Electricity Generation Certificate? Why or why not?	The purpose of the target was stated as stimulating the WA hydrogen industry. CarbonTP do not see how including other fuels would achieve this objective unless the alternatives are derived from hydrogen, in which case they would be even more expensive to produce and less attractive to use.
Setting a target		

No.	Question	Feedback
11	Please consider the benefits, costs and implications of a 1%, 5% and 10% Renewable Hydrogen Target for electricity generation in the SWIS on your business or industry, and provide commentary on how you would expect to react from a commercial and investment perspective to each target level.	CarbonTP's perspective is that these targets will make wholesale electricity substantially more expensive. Our estimated all in cost of hydrogen derived electricity with current technology is $750/MWh. Therefore at 1% penetration this would add ~$7.50/MWh to the average wholesale cost of power generation and at 10% penetration it would add ~$75 per MWh. i.e., hydrogen will only serve to raise electricity prices significantly with limited impact on emissions.
12	At a whole-of-economy and / or sectoral level, what do you consider to be some of the benefits, costs and implications of a 1% target, a 5% target, and a 10% target?	CarbonTP perceive only downside to any hydrogen based electricity generation, with any target only serving to make electricity more expensive and with a very high cost of abatement in excess of $1,000 per tonne of CO2.
Target terms		
13	Is the suggested approach of a medium term aggregate target, with annual entity targets, an efficient and effective means to achieve the objectives of the Renewable Hydrogen Target for electricity generation in the SWIS? Why or why not?	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
14	To what extent should banking and borrowing of liabilities be permitted under the scheme? What are the benefits and costs of a borrowing mechanism as described in the paragraph above?	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
Scheme commencement and ramp up		
15	How soon do you believe a Renewable Hydrogen Target for electricity generation in the SWIS could be feasibly delivered from a technical perspective (i.e. if cost was not a consideration)? Please reflect on your own organisation and/or sector when providing your answer.	CarbonTP's perspective is that if cost were no object it would take a minimum of 5 years to deliver the 1% target, however the cost of doing this would likely be in the order of dollars per kilogram.
16	Similar to the above, how soon do you believe a Renewable Hydrogen Target for electricity generation in the SWIS could be feasibly delivered from a commercial or economic perspective (i.e. if cost was a consideration)? Please reflect on your own organisation and/or sector when providing your answer.	CarbonTP's perspective is that using hydrogen for electricity generation with currently available technology is not remotely commercially viable and therefore a renewable hydrogen target in the SWIS will never be delivered from an economic perspective.

No.	Question	Feedback
17	Over what period of time do you believe is an appropriate ramp up period for the Renewable Hydrogen Target for electricity generation in the SWIS? In providing your answer reflect on the actions your organisation and / or sector would need to take to participate in the scheme.	As noted above, CarbonTP believes that electricity generation using hydrogen should not be incentivised.
Hydrogen cost outlook		
18	In the short (<5 years), medium (5-15 years) and long (15+ years) term, where do you expect the cost of production of renewable hydrogen to move from the estimated levels of today? What do you expect to be the drivers of this change?	CarbonTP's perspective is the cost of production will decline slowly but the relatively large and rapid price drops forecast will not happen for the following reasons: The forecast cost reductions mainly rely on super cheap renewable energy, which, if it becomes available, will make all the alternatives to hydrogen across all energy based use cases a lot cheaper, and therefore there will be no additional incentive to use hydrogen as the price comes down The cost reductions rely on massive scale up of electrolyser manufacturing but that assumes lots of expensive electrolysers will be sold initially to generate that price decline. This in turn assumes lots of very expensive hydrogen will be sold on long term contracts to achieve the required scale. CarbonTP do not see this as a likely scenario Additionally, the cost reduction of electrolysers due to Wright's law will eventually happen, but the balance of system costs, which account for ~50% of the overall capex for a hydrogen manufacturing facility, will not reduce by much at all, as these components are all mature technology with limited room for improvement and a huge manufactured base requiring very large numbers of additional units to be sold to generate any price decline. The cost of transporting and storing hydrogen in any form make it highly unattractive as an energy vector and from CarbonTP's perspective, the notion that it will become a globally traded commodity is seriously misguided. None of the major announcements made so far regarding hydrogen production

No.	Question	Feedback
		facilities have achieved FID or been accompanied by a legally binding offtake contract with an agreed price because the economics will not work. The current unprecedented peak in global gas prices make hydrogen appear to be a potentially viable alternative, however these prices are crippling industries which is exactly what will happen if they switch to hydrogen fuel. Additionally global gas prices are unlikely to stay at this level for an extended period with significant additional LNG capacity coming on line from Australia, the US and Qatar amongst others. Note: Wright's law is a general rule applied to manufactured goods that states there is a constant learning curve, whereby the cost of manufacture declines by a fixed percentage for every doubling of total installed capacity.
Hydrogen demand and electrolyser capacity		
19	To what extent to you believe the above scenarios are reasonable and achievable? Please explain your answer with reference to your previous answers regarding the objectives of the scheme.	CarbonTP do not believe the above scenarios are either reasonable or achievable for the reasons articulated in our previous answers. The use of hydrogen for electricity generation will be cost prohibitive and result in an extremely high unit cost of emissions abatement.
20	How would you expect the levels of hydrogen demand for electricity generation in the SWIS to be met at various points in the supply chain? Would you expect a single generator would emerge and provide all certificates?	Renewable hydrogen requires huge quantities of renewable electricity. CarbonTP estimate an initial total supply chain efficiency including compression and transport of ~20% from renewable energy in, to electrical power out. To replace only 1% of the SWIS, i.e., 180GWh with renewable hydrogen generation would require approximately 400MW of dedicated new solar capacity at ~27% capacity factor, or ~230MW of new wind capacity at ~45% capacity factor, together with matching electrolyser capacity. The total scale of investment required in renewable infrastructure, electrolysers and balance of plant, and transport and storage infrastructure is Est. AU$1-1.5 billion Additionally, given the scale of the renewables required it is likely they will come from multiple sources.

No.	Question	Feedback
		(180GWh at 20% system efficiency requires 180/0.2 = 900GWh of renewable generation. 900,000MWh generated over 8760 hours in a year at 27% capacity factor requires 900,000/0.27/8760 = ~380MW of solar capacity)
21	Would you expect one very large renewable hydrogen producer, a number of very small renewable hydrogen producers, or some other combination, to emerge in the State as a result of the scheme? Alternatively, would a domestic-focused producer have sufficient scale to operate in a domestic market only?	As per above comment the scale of renewables required suggests that multiple facilities would be required at a number of locations. Additionally given the high cost of transporting hydrogen it would make sense to have the producers as close as possible to the offtakers making multiple producers a more likely scenario From CarbonTP's perspective, domestic production of hydrogen is the only type of hydrogen production that makes sense. The technical difficulties and costs involved with storing and transporting hydrogen overseas will likely overshadow any cost reductions in manufacturing. CarbonTP believe the concept of using hydrogen as an energy vector / fuel is fundamentally flawed due to the laws of thermodynamics and inherent properties of the hydrogen molecule. CarbonTP believe the WA government should invest in incentivising energy intensive industries to relocate here using our plentiful and high-capacity factor renewable resources to manufacture low carbon ammonia, steel, aluminium etc. becoming a low carbon industrial superpower and exporting renewable energy locked into energy intensive commodities.