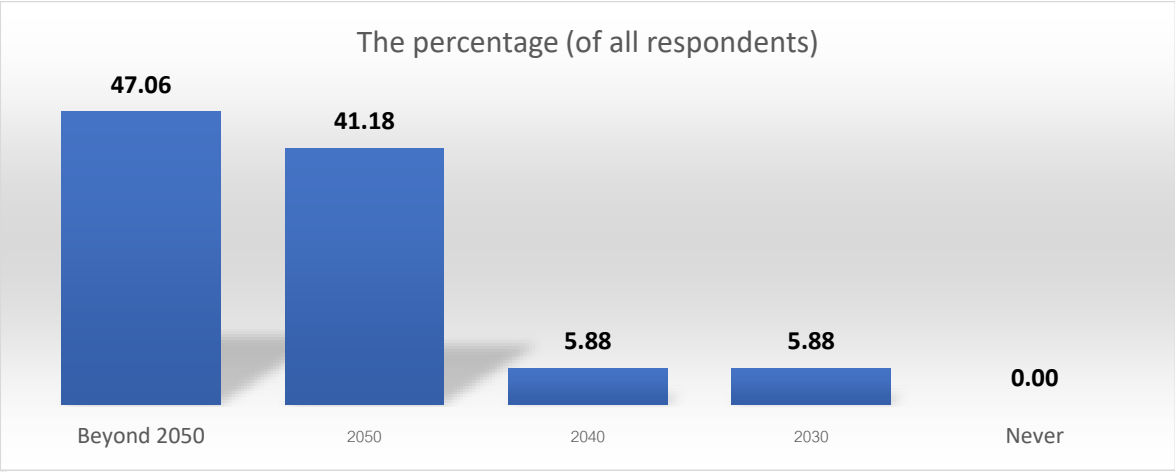
DELPHI SURVEY RESULTS
ISSUE 2:
ENERGY TRANSITION

Energy transition refers to a broad shift in technologies and behavior that are needed to replace one source of energy with another. The current episode of energy transition is driven by significant decarbonization of the energy sector, specifically a shift away from fossil-based primary energy sources (including coal, oil, and natural gas) to primary renewable energy sources (such as solar and wind).

APEC's energy mix is dominated by fossil fuels - 86 percent of the total primary energy supply and 75 percent of electricity supply. Nonetheless, the region is also experiencing rapid transitions to clean energy, including increased renewable energy within the electricity supply mix, and a choice of hydrogen in final energy. The management and governance of energy transitions involve both technological changes and socio-economic-environmental aspects. They are characterized by large uncertainties and ambiguities that would require an understanding of how these transitions will evolve in the future.

Hence, this part of the survey will focus primarily on the supply-side of the energy transition, namely, electricity supply (Part 2.1) and hydrogen economy (Part 2.2).

1. When are you likely to see the energy supply transition fully take place (i.e., in line with net-zero emissions) in APEC?

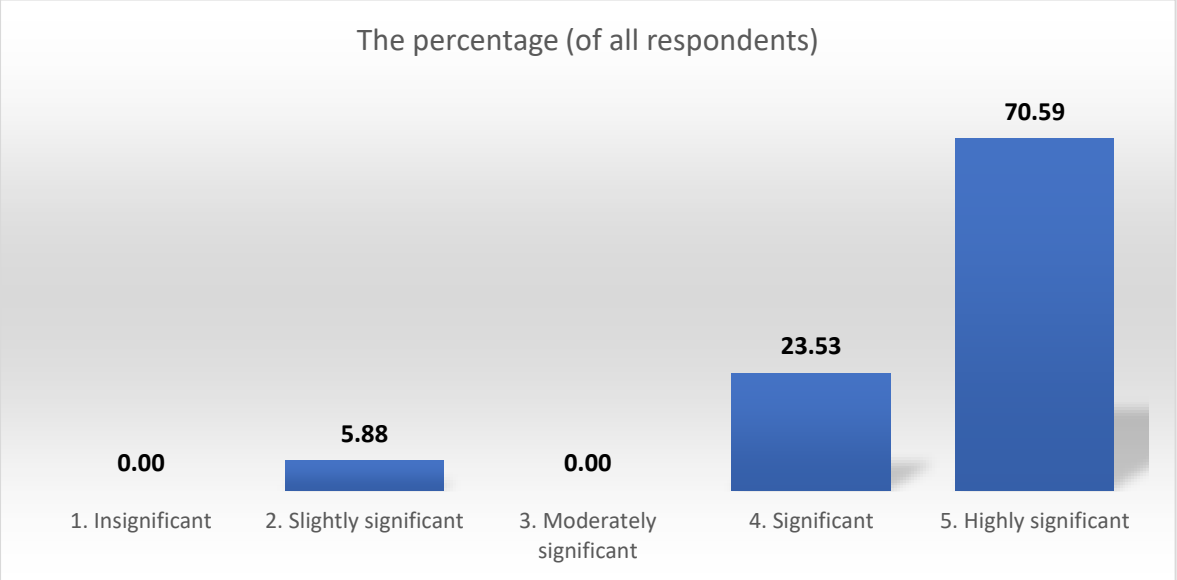


Opinions	Comments
Beyond 2050	▪ The transition is slower than expected. ▪ Little energy transition in sight up to now. ▪ It is a slow process sometimes also due to fears and trade aspects.
2050	▪ The cleanliness of electricity supply constitutes a prerequisite for the energy transition. In order to accomplish zero emissions within

Opinions	Comments
	the energy system, it is imperative to first achieve zero carbonization of electricity supply, whereupon green electricity can be utilized to facilitate zero carbonization across other industrial sectors. 2050 will serve as a critical milestone, as the largest energy consumer within APEC, China, aims to attain carbon neutrality by 2060, necessitating the zero carbonization of its electricity supply at least a decade in advance. ▪ most already pledge to reach net zero by 2050.
2040	▪ APEC is in the process of adjustment which requires technology transfer and a lot of investment. Therefore, it takes time to transition.
2030	-
Never	-

2. On a scale of 1 to 5, how significant will the following technologies be in the decarbonization of your economy by 2050?

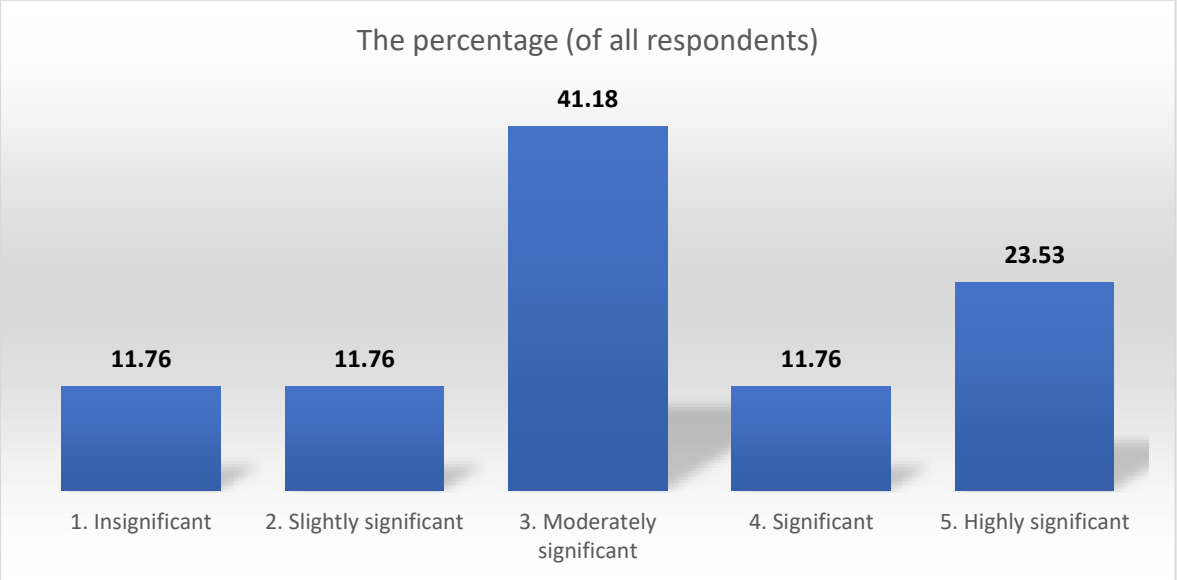
<u>a. Electrification with renewable energies</u>



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	▪ Renewables only contributes 3% total energy in 2022. Lots of misinformation about renewable energy installations exist. Energy transition will not come at faster pace in recent years.
3. Moderately significant	-
4. Significant	▪ By then, technology should have already matured and reached economies of scale for all member economies to afford. ▪ The need of energy is big.
5. Highly significant	▪ The GHG emissions are directly relevant to the Res. ▪ China's zero-carbon electricity generation is predominantly

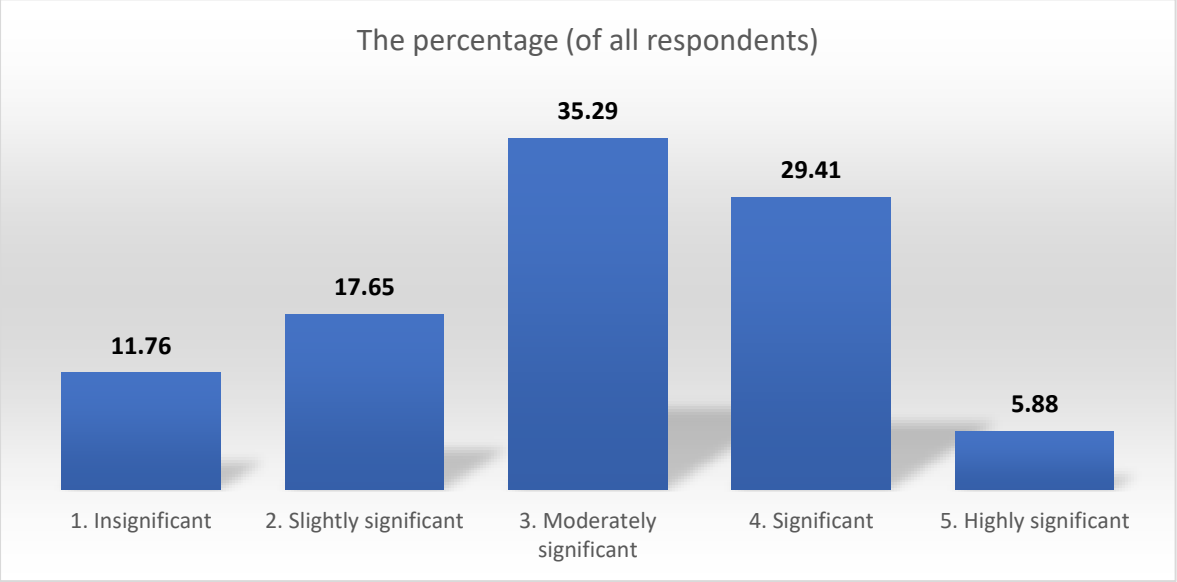
Level of significant	Comments
	sourced from renewable energy and nuclear power. The expansion of nuclear power in China is, however, hindered by site-related constraints, resulting in a relatively limited development scale. In order to achieve extensive zero-carbon electricity supply, China must therefore rely heavily on renewable energy sources, particularly wind and solar photovoltaic technologies.

b. Electrification with fossil fuel and CCS



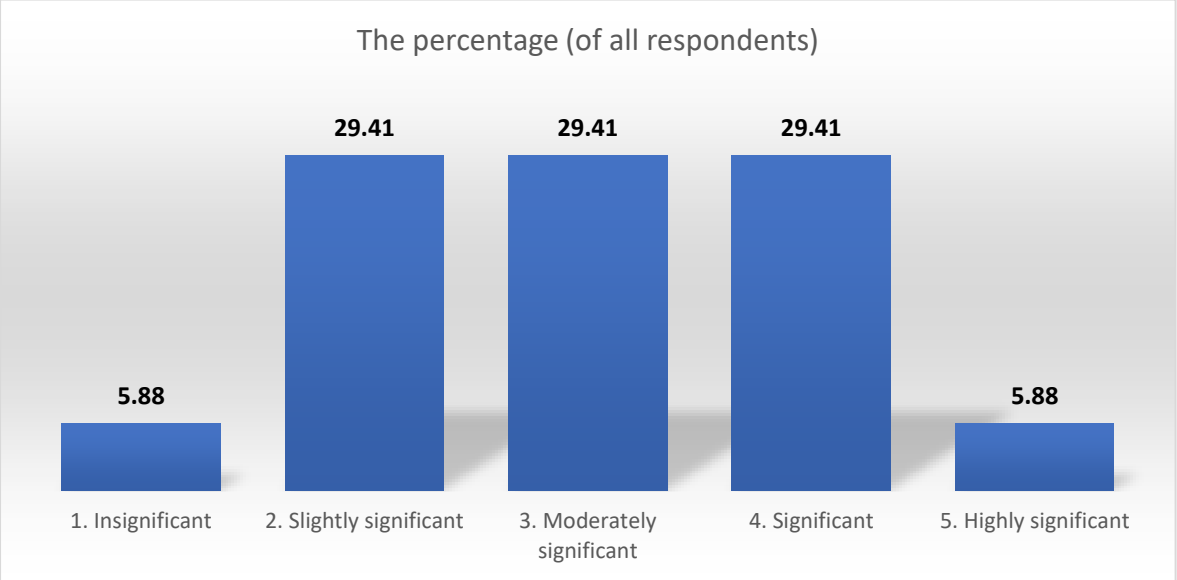
Level of significant	Comments
1. Insignificant	▪ No successful CCS project exists yet. In addition, they are expensive, and quantity are small comparing to what we are emitting now. ▪ No successful CCS project associated with electricity generation exists yet. In addition, they are expensive and quantity are small comparing to what we are emitting now.
2. Slightly significant	▪ Not quite sure about ccs will become economically feasible for most member economies.
3. Moderately significant	▪ Less impact than REs and the feasibility of the CCS is not that high. ▪ Small local economies are not ready to change all their energy generation technology.
4. Significant	-
5. Highly significant	▪ Renewable energy sources are inherently unstable, and the large-scale development of renewable energy cannot be achieved without the support of fossil fuels. Even during the zero-carbon phase, a portion of fossil fuel-powered generators are needed as power sources. The energy produced by these units must be decarbonized through the use of CCS technology, making fossil fuel-powered generators and CCS technology equally important.

c. Electrification with nuclear power



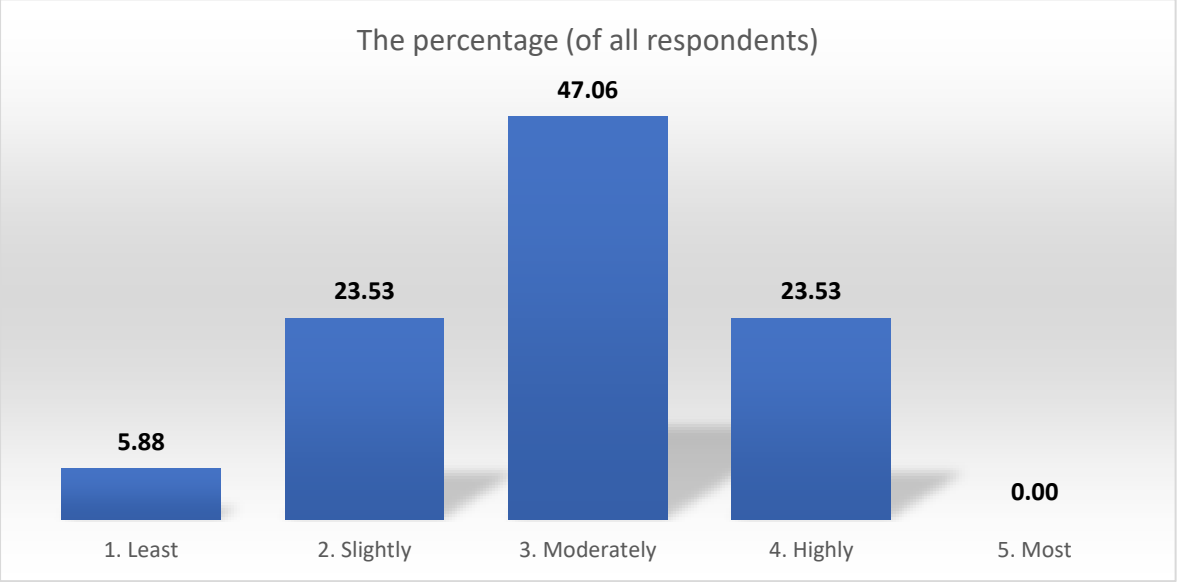
Level of significant	Comments
1. Insignificant	▪ All nuclear reactors will retire by 2025. ▪ All nuclear reactors in Taiwan will retire by 2025. ▪ Not sure nuclear will be taken up by more member economies in the future.
2. Slightly significant	-
3. Moderately significant	▪ The problem is the public perception. ▪ The percentage of acceptance has become weaker.
4. Significant	▪ The operation cost is cheap. ▪ Nuclear power represents a pivotal zero-carbon energy source; however, its development is significantly constrained by site limitations, resulting in a comparatively diminished contribution to the vast scale of China's electricity requirements.
5. Highly significant	-

d. Fossil-based hydrogen economy and CCS



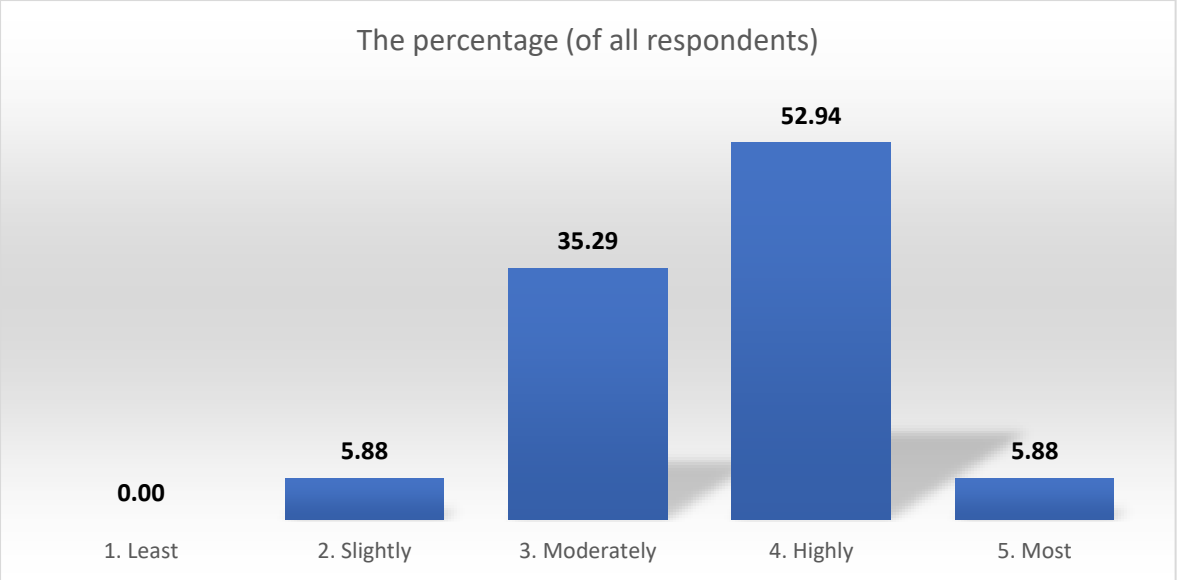
Level of significant	Comments
1. Insignificant	▪ Although IPCC Special report on Carbon Dioxide Capture and Storage (SRCCS) released in 2005, world has not seen a successful CCS-power generation project. I do not put much faith in CCS in the next 20 years. In addition, questions remain on how safe the storage will be, and what the leakage rate is 'acceptable'.
2. Slightly significant	▪ We need to phase out fossil fuel and the application of hydrogen and CCS is not easy. ▪ Possible as hydrogen is starting to emerge as cleaner alternative of energy.
3. Moderately significant	▪ I believe that the rapid advancement of renewable energy and electrolytic hydrogen production technologies will result in a swift decline in the cost of green hydrogen, rendering it more competitive compared to hydrogen produced from fossil fuels with CCS technology.
4. Significant	▪ It will probably be more accepted.
5. Highly significant	-

3. On a scale of 1 to 5, how likely will there be an earlier phase-out of fossil fuel infrastructure (i.e., earlier than its economic life) to meet net-zero emissions in APEC?



Level of opinion	Comments
1. Least	-
2. Slightly	▪ Some countries are still reeling in fossil fuels production and the economy is too small to diversify due to insufficient resources.
3. Moderately	▪ The deployment of REs are slower than expected. ▪ The rate at which fossil fuel infrastructure is retired is contingent upon the pace of renewable energy development. If renewable energy development surpasses projections, it may precipitate the early retirement of fossil fuel infrastructure; conversely, if it fails to meet expectations, fossil fuel infrastructure will continue to be employed. Nonetheless, safeguarding energy supply security remains the paramount consideration in energy development. ▪ Really hard to phase-out of fossil fuel before 2050.
4. Highly	▪ It depends on awareness and behavior.
5. Most	-

4. Based on your answer in Question 3 (above), and on a scale of 1 to 5, how likely would there be tangible impacts of phasing out from fossil fuel infrastructures on small local communities across APEC economies?



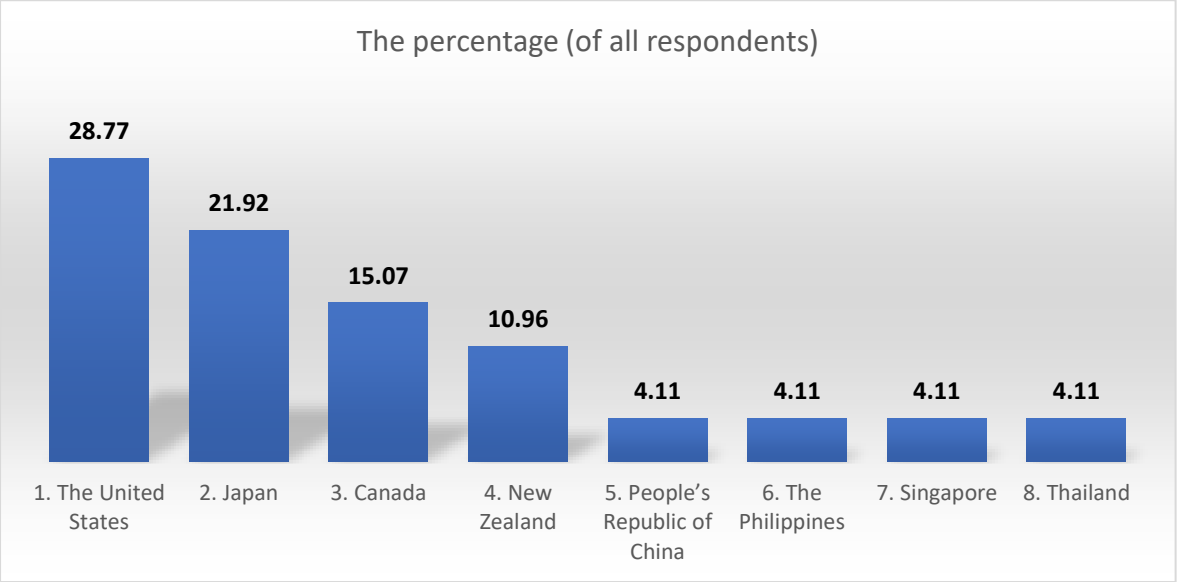
Level of opinion	Comments
1. Least	-
2. Slightly	-
3. Moderately	▪ It is needed but urban and rural life need better governance, better communication and should decentralize managerial aspects too.
4. Highly	▪ The local communities are highly dependent on the fossil fuel. ▪ The response to this inquiry is multifaceted. For small economies that have successfully implemented a distributed and resilient power system, the retirement of fossil fuel infrastructure would have a comparatively diminished impact. Conversely, if these economies have not developed a power system tailored to the unique characteristics of new energy sources, the elimination of fossil fuel infrastructure would prove more consequential. Given the substantial technical demands and investment requirements associated with the development of a power system aligned with the characteristics of new energy sources, it is probable that the overall energy supply in these regions would be significantly affected.
5. Most	▪ This will affect the communities' welfare.

2.1 Electricity Supply

Electricity supply refers to the network of components needed to generate, transmit, distribute, and supply electric energy to various demand sectors of the economy. It comprises of an electricity-generation system that converts primary energy (fossil and non-fossil) into electrical energy, and transmission-and-distribution systems (centralized and decentralized networks) to deliver electrical energy for final usage.

1. Based on your justification, please select APEC economies that are most and least responsive to decarbonizing their electricity system towards net zero by 2050.

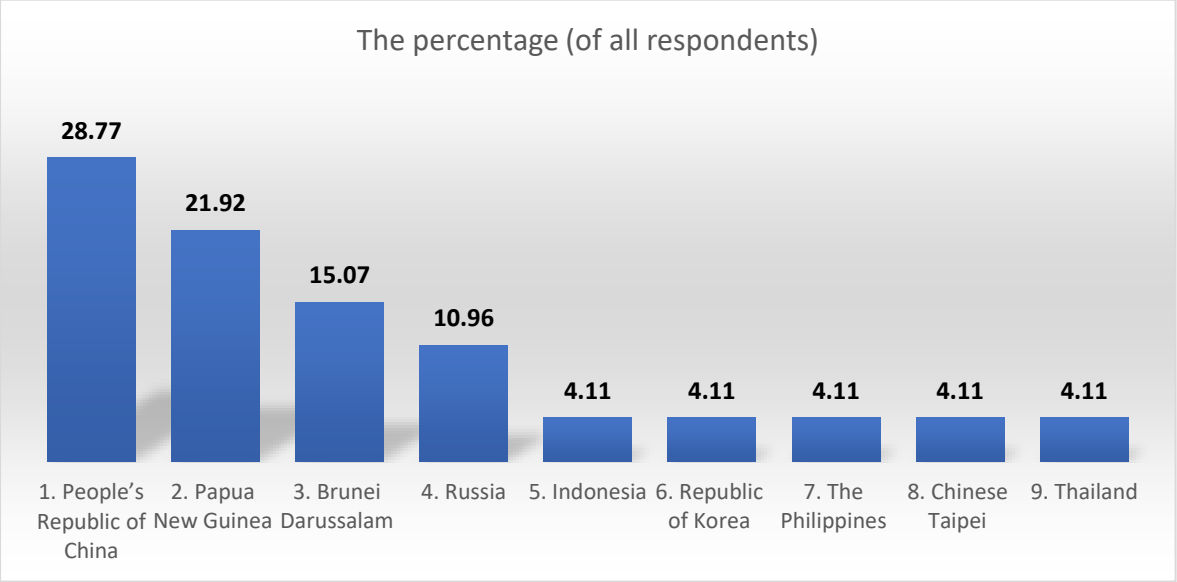
a. Most responsive



APEC economies	Comments
1. The United States	-
2. Japan	▪ Very eager to apply REs.
3. Canada	-
4. New Zealand	▪ NZ are always pushing for phase out of fossil fuel. ▪ New Zealand has set ambitious targets for renewable energy and has been actively working towards decarbonizing its electricity system. The country has a goal of 100% renewable electricity by 2030 and aims to achieve net-zero emissions by 2050.
5. People's Republic of China	▪ China's substantial power demand is primarily satiated by fossil-based electricity, resulting in immense pressure to transition towards a zero-carbon power system. However, China has resolutely committed to achieving carbon neutrality by 2060, a target that will catalyze the transformation of a vast scale of renewable power. Additionally, the manufacturing industry that emerges from this transformation will have a spillover effect, providing support and driving the transition towards renewable power systems in other regions.

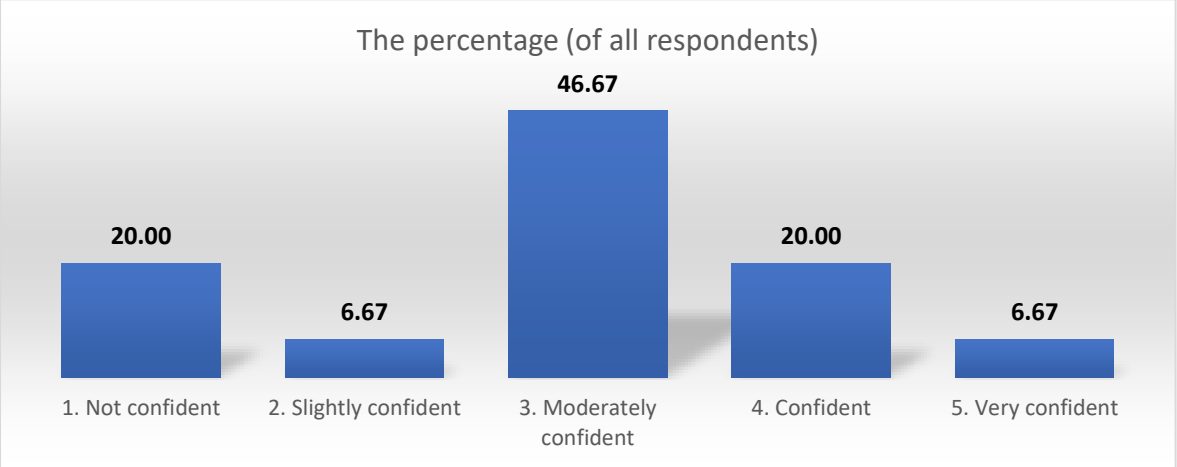
APEC economies	Comments
6. The Philippines	▪ Limited consumption of fossil fuels, therefore small carbon dioxide emission, in addition to some existing geothermal energy, makes the Philippines relatively easier to go net zero by 2050.
7. Singapore	-
8. Thailand	-

b. Least responsive



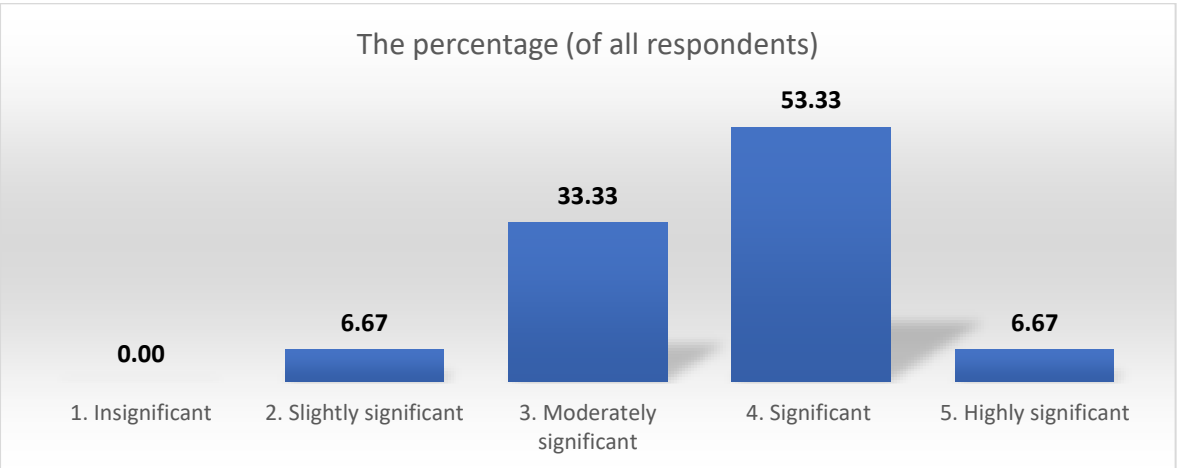
APEC economies	Comments
1. People's Republic of China	▪ Still one of the highest emitter. ▪ While China is making efforts to increase the share of renewables in its energy mix, it faces challenges due to its significant reliance on coal. The country has set a goal to reach peak carbon emissions before 2030 and achieve carbon neutrality by 2060, but the transition is complex due to the scale of its energy infrastructure.
2. Papua New Guinea	-
3. Brunei Darussalam	-
4. Russia	-
5. Indonesia	-
6. Republic of Korea	▪ ROK keeps lowering its renewable energy target, plans to replace coal power plants with gas fired plants.
7. The Philippines	▪ It has many islands and not providing good strategy.
8. Chinese Taipei	▪ Chinese Taipei's limited land area constrains the development of renewable energy power. Moreover, the anti-nuclear movement hinders the advancement of nuclear power. Additionally, the regional impact is relatively minimal.
9. Thailand	-

2. On a scale of 1 to 5, how confident do you perceive APEC economies to effectively collaborate on cross-border electricity trading towards achieving net-zero emissions?



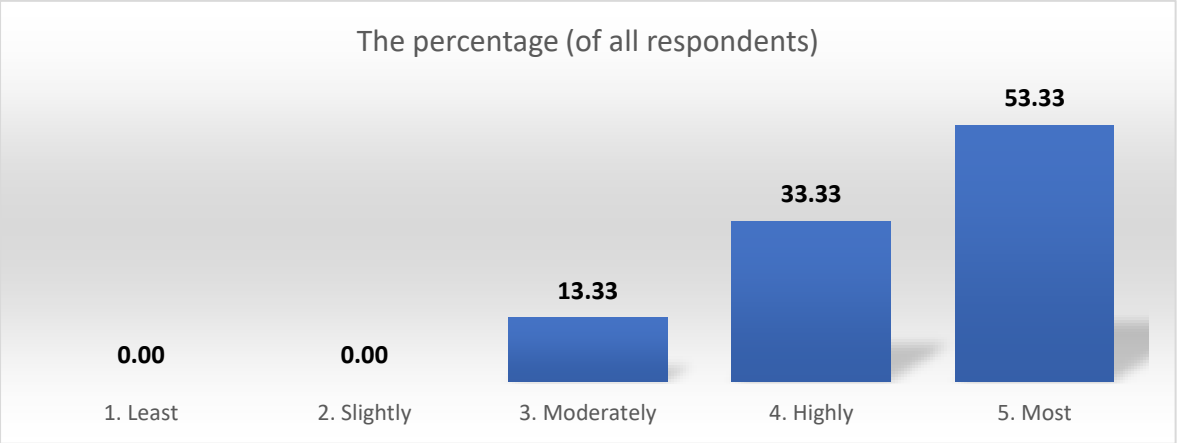
Level of confident	Comments
1. Not confident	▪ I could not see any active efforts. ▪ Regulations has to be harmonized.
2. Slightly confident	-
3. Moderately confident	-
4. Confident	▪ Some countries within the APEC region share contiguous geography, possessing the conditions for cross-border electricity trading, and have engaged in cooperation. As energy cooperation in the APEC region deepens in the future, the complementarity of cross-regional renewable energy generation will increase, leading to effective collaboration in cross-border electricity trading.
5. Very confident	-

3. On a scale of 1 to 5, how desirable is it to achieve a 100% renewable energy target in electricity generation in your economy?



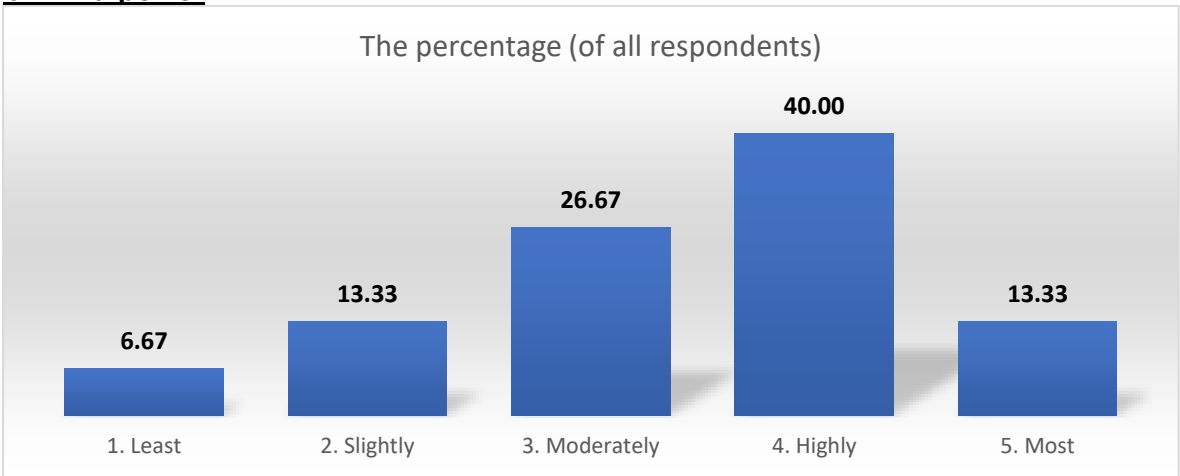
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ As a large country with a substantial power consumption scale, ensuring power supply security is the primary objective in China's power development. Achieving a 100% renewable power system is not necessarily a mandatory goal, and it may not be an economically or efficiency-oriented objective. In contrast, pursuing a high proportion of renewable energy under the premise of power supply security, based on the development of renewable energy, energy storage, and hydrogen technologies, may be a more scientific approach.
4. Significant	▪ Highly desirable.
5. Highly significant	▪ It is one of highest energy importing country.

4. On a scale of 1 to 5, how significant will the following technologies be in the electricity supply system in your economy to achieve net-zero emissions?
a. Solar power



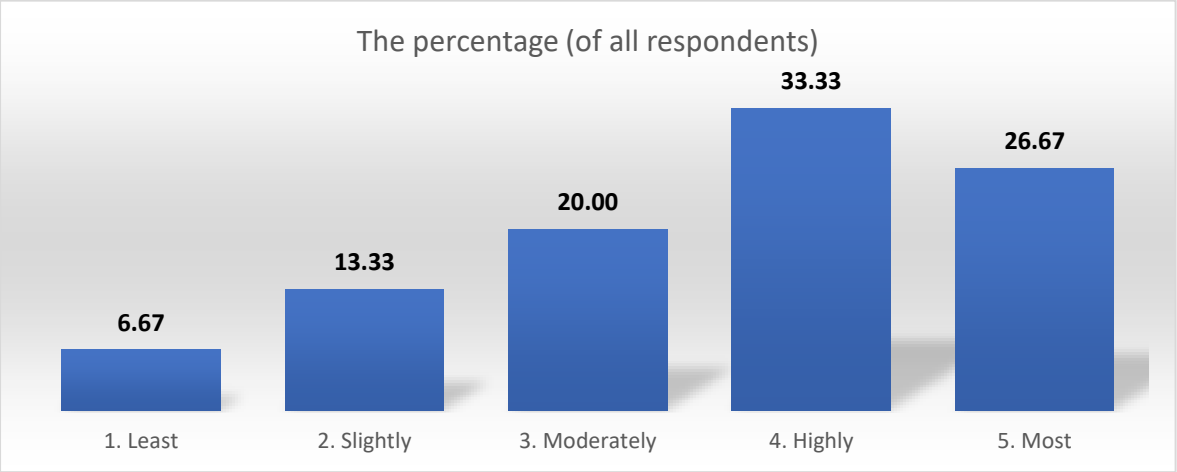
Level of significant	Comments
1. Least	-
2. Slightly	-
3. Moderately	▪ Small land size and low stakeholder support.
4. Highly	-
5. Most	▪ China's vast territory offers immense potential for solar energy development, and the country's strong photovoltaic manufacturing capabilities enable it to provide the necessary battery components for the large-scale expansion of solar power. ▪ Most viable.

b. Wind power



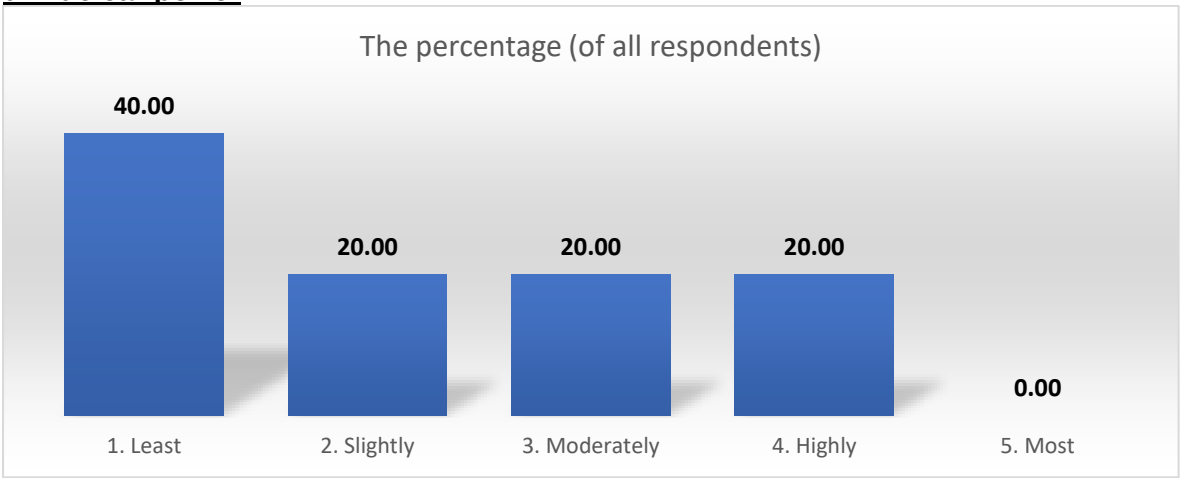
Level of significant	Comments
1. Least	▪ Not viable.
2. Slightly	-
3. Moderately	▪ The quality and quantity is not at good level.
4. Highly	▪ China's vast potential for wind energy positions it as a significant component of future zero-carbon power systems. However, compared to solar energy, wind power is more significantly impacted by geographical factors, resulting in a development scale that is not as extensive as that of photovoltaic power generation.
5. Most	-

c. Hydro power



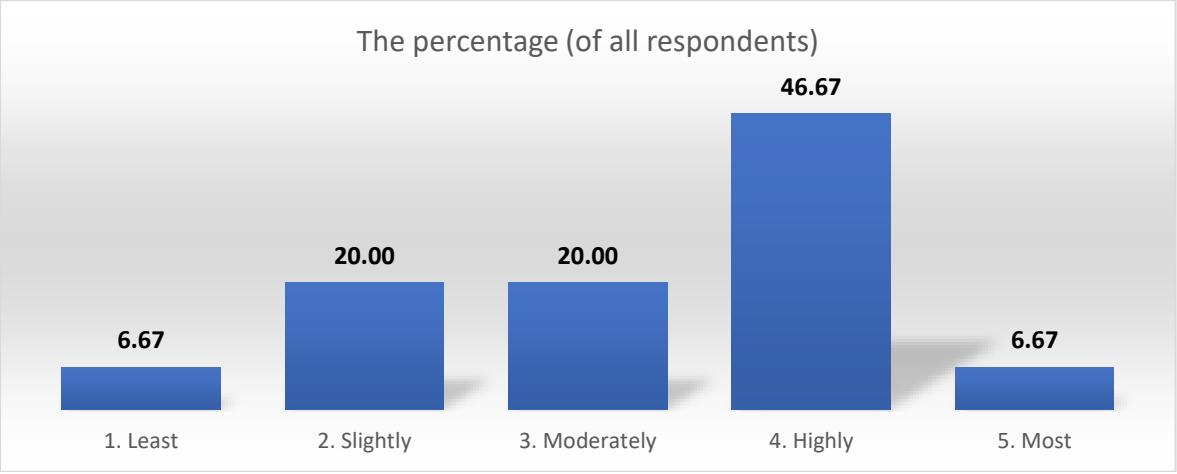
Level of significant	Comments
1. Least	▪ Not viable.
2. Slightly	-
3. Moderately	▪ The land size is small. So, it can't accommodate many dams.
4. Highly	▪ China's hydropower resources have been highly developed, leaving limited room for future expansion.
5. Most	-

d. Nuclear power



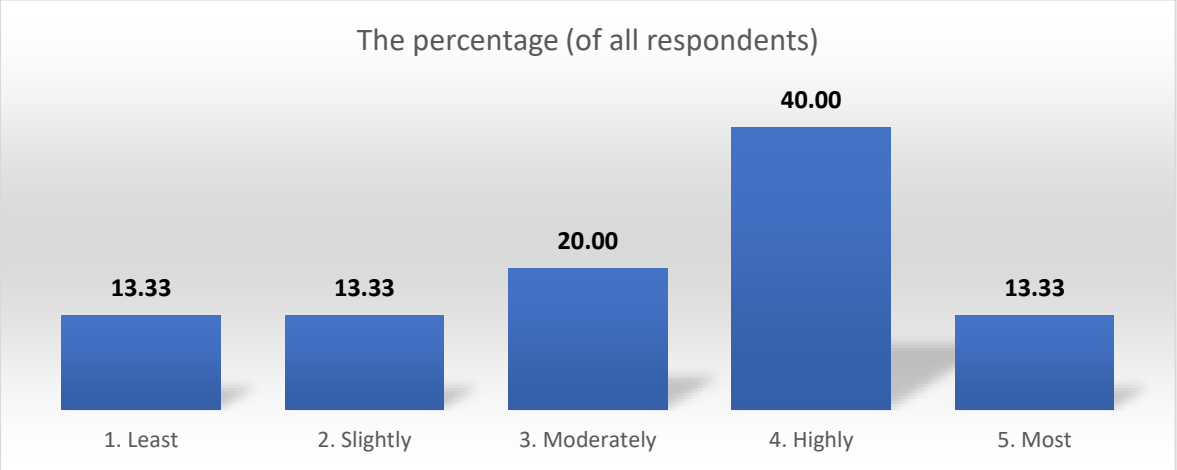
Level of significant	Comments
1. Least	▪ Not viable.
2. Slightly	-
3. Moderately	▪ China's nuclear power is expected to undergo significant expansion; however, it is constrained by site factors, limiting its future growth potential. As a result, its contribution to zero-carbon power systems will be less substantial compared to wind and solar power.
4. Highly	▪ It has many facilities.
5. Most	-

e. Bioenergy



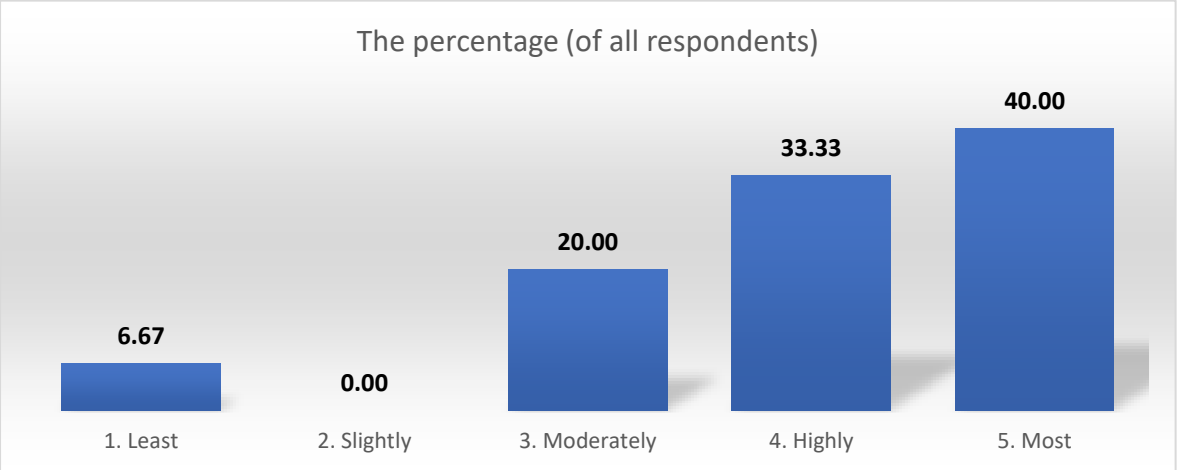
Level of significant	Comments
1. Least	▪ Not viable.
2. Slightly	▪ China's biomass energy is still in its early stages of development, and due to resource constraints, its future growth potential is limited. Consequently, its contribution to zero-carbon power systems will be less significant compared to wind and solar power.
3. Moderately	▪ The land size is small.
4. Highly	-
5. Most	-

f. Fossil-based electricity with carbon capture and storage



Level of significant	Comments
1. Least	▪ Not viable.
2. Slightly	▪ The land size is small, and the underground structure is not supporting.
3. Moderately	-
4. Highly	▪ Fossil power with carbon capture and storage (CCS) is an indispensable component of future new energy power systems, playing a critical role in providing a safety net for the entire power system.
5. Most	-

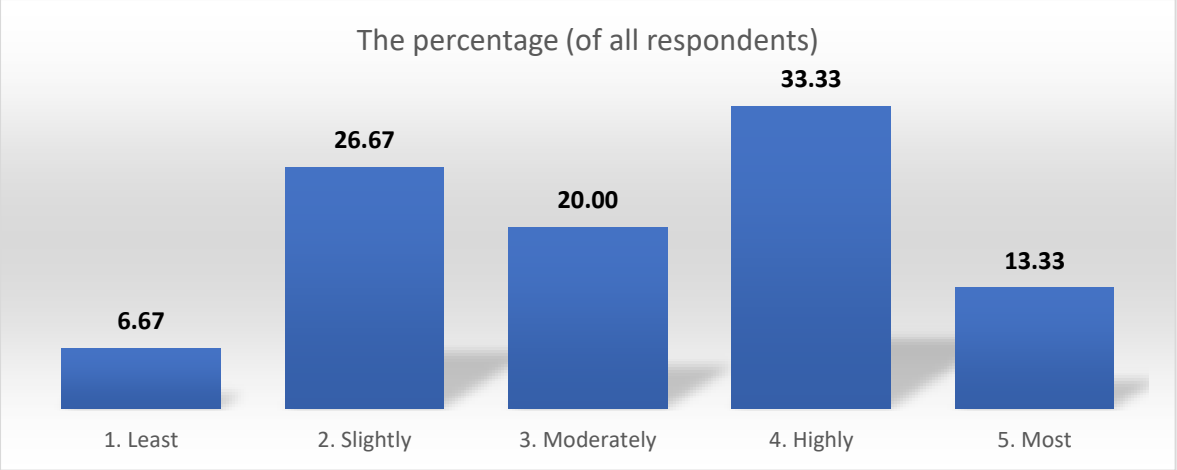
g. Lithium battery for electricity storage



Level of significant	Comments
1. Least	▪ Not sure if viable.
2. Slightly	-
3. Moderately	-
4. Highly	-
5. Most	▪ It has high technology maturity. ▪ Energy storage is an indispensable component of new energy power systems, with lithium-ion batteries

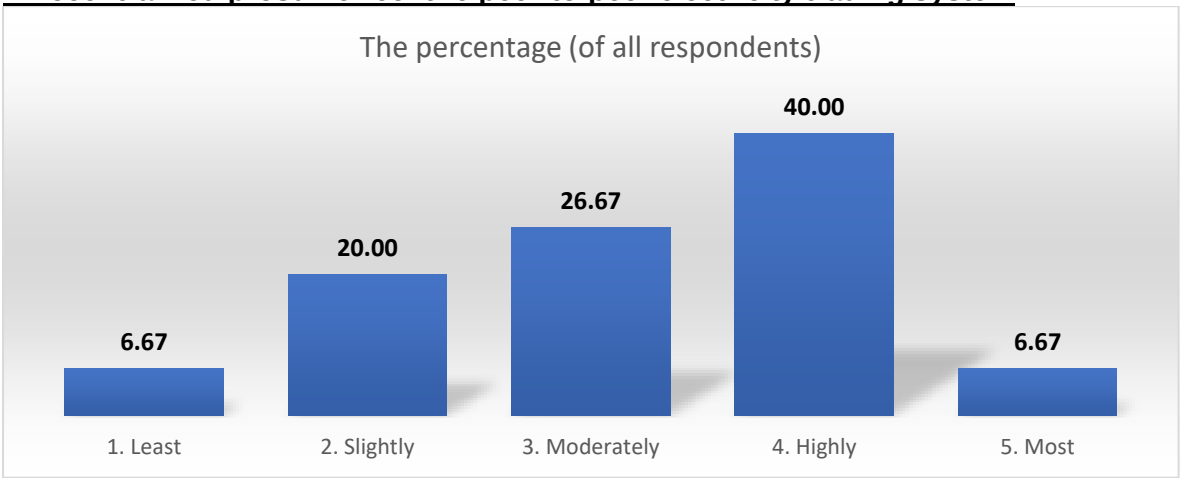
Level of significant	Comments
	being the most mature technology currently available. They are expected to play a significant role in the future.

h. Other chemical electricity storage



Level of significant	Comments
1. Least	▪ Not sure if viable.
2. Slightly	▪ It is not competitive.
3. Moderately	-
4. Highly	▪ Other chemical energy storage solutions will play a crucial role in future energy storage systems. As advancements are made in these alternative technologies, they may potentially outperform lithium-ion batteries in terms of economic efficiency and safety, creating a complementary relationship with lithium-ion battery storage.
5. Most	-

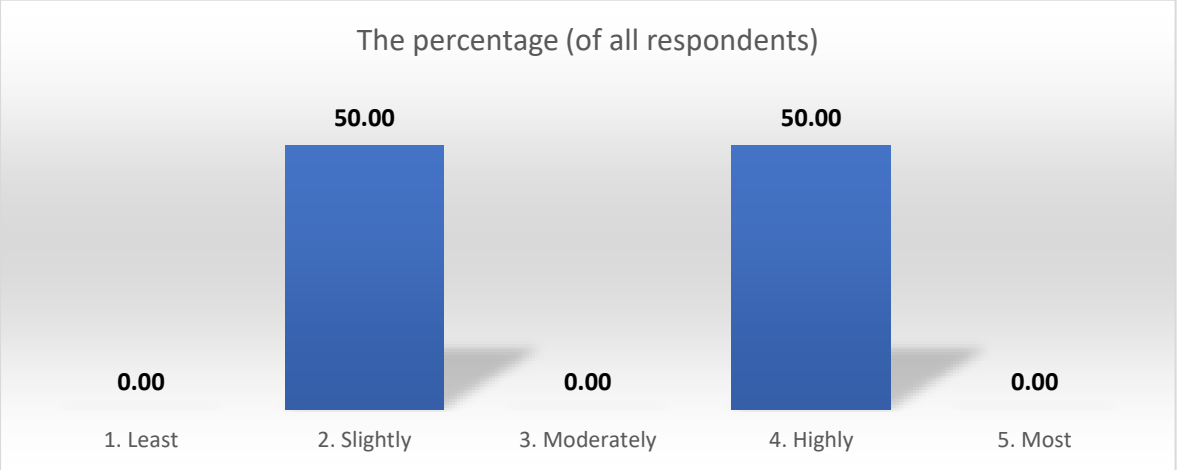
i. Decentralized prosumer-centric peer-to-peer electricity trading system



Level of significant	Comments
1. Least	▪ Not sure of the meaning.
2. Slightly	▪ The population is not high.

Level of significant	Comments
3. Moderately	-
4. Highly	▪ Distributed renewable power systems are an essential component of future power systems, and the corresponding electricity market will also promote the economic and sustainable development of this model.
5. Most	-

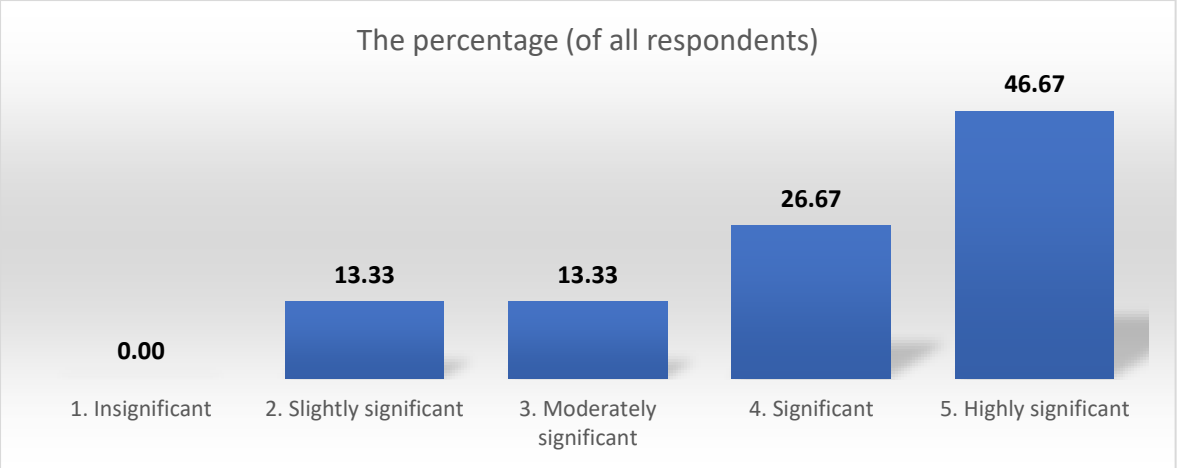
j. Others



Level of significant	Comments
1. Least	-
2. Slightly	[other: Tidal energy] ▪ Surrounded by three oceans but the resource is not supportive
3. Moderately	-
4. Highly	[other: green hydrogen] ▪ In my opinion, green hydrogen represents a viable means for the long-term and large-scale storage of renewable electricity in the future.
5. Most	-

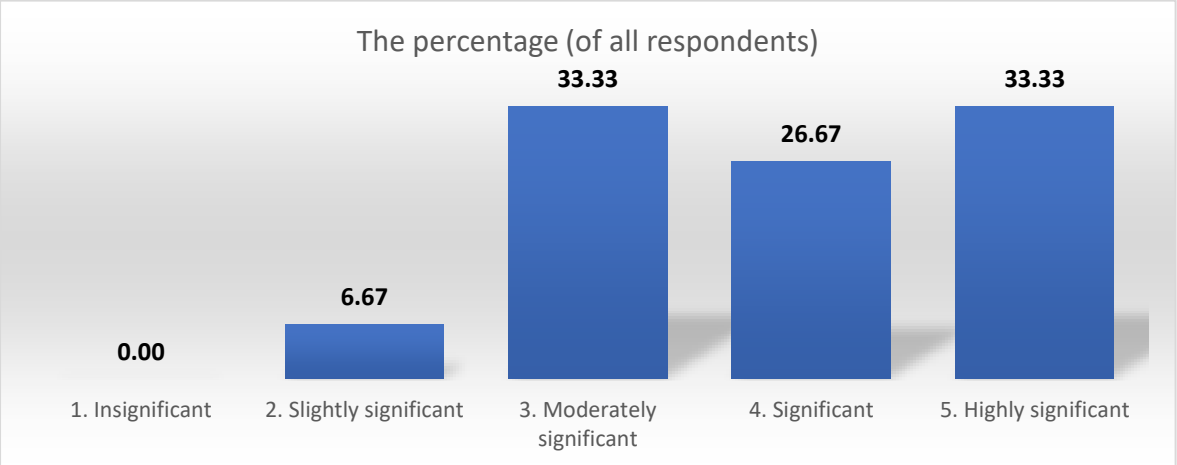
5. Based on your justification, how significant are the following barriers to achieving low carbon electricity systems across APEC economies?

a. Intermittency of renewable energy sources



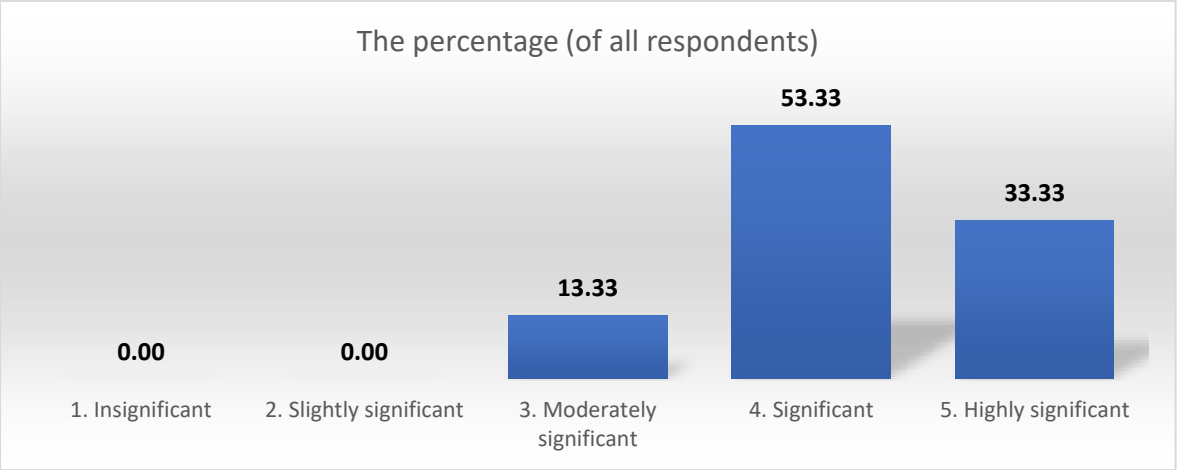
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	▪ It is the natural characteristics of renewable energy source.
5. Highly significant	▪ Electricity supply necessitates consistent, uninterrupted, and real-time delivery. The intermittent nature of renewable energy sources presents significant challenges for power system operations, necessitating substantial investments in both technology and financial resources to overcome. For renewable energy to achieve widespread, high-proportion adoption, it must successfully address the issues of intermittency and instability. ▪ Affects the energy being produced

b. Insufficient energy storage capacities



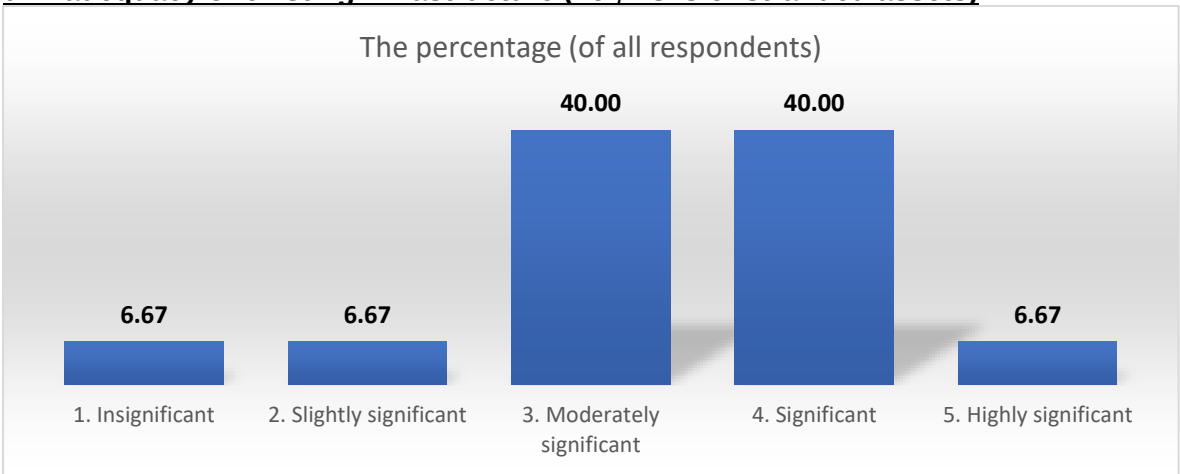
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	-
5. Highly significant	▪ There are wasting of the produced energy. ▪ To address the intermittency issues of renewable energy sources, large-scale energy storage capacity is required. ▪ Unable to store enough energy for consumption and for backup.

c. Modernization of grid infrastructure



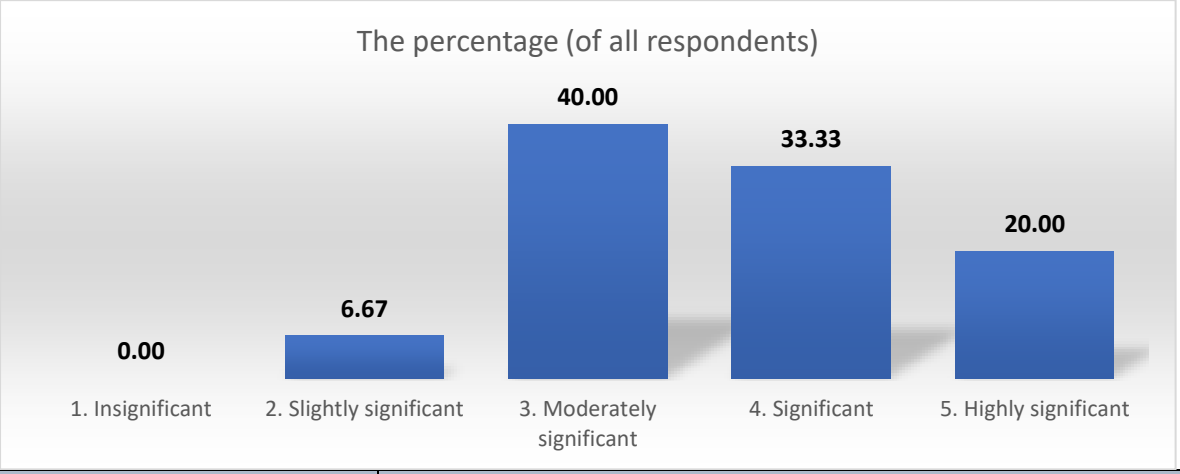
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	▪ We need to remove the energy loss.
5. Highly significant	▪ Smart grid infrastructure is a fundamental prerequisite for the utilization of renewable energy sources, making it of significant importance. ▪ Will ensure efficiency.

d. Inadequacy of existing infrastructure (i.e., risks of stranded assets)



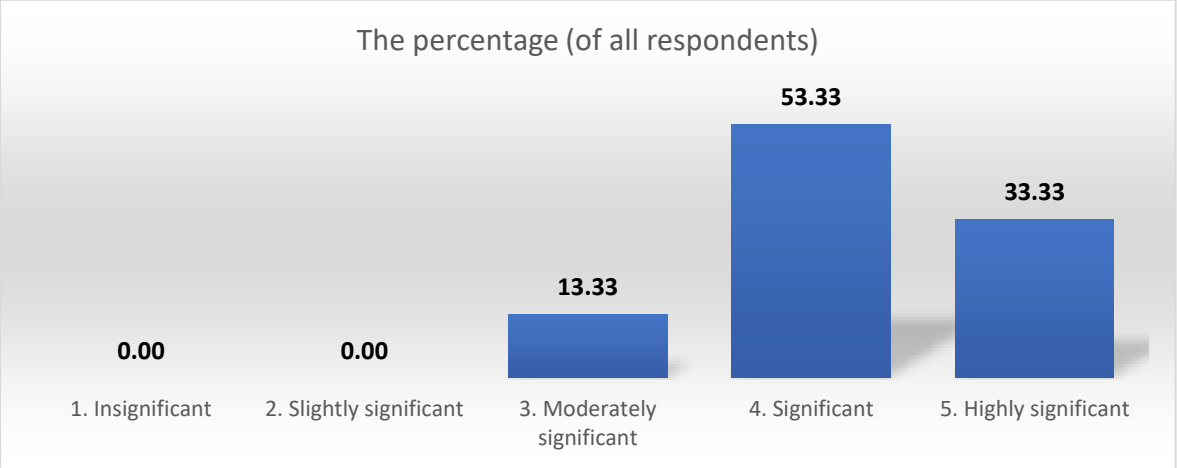
Level of significant	Comments
1. Insignificant	▪ Not sure of the meaning.
2. Slightly significant	-
3. Moderately significant	-
4. Significant	▪ The existing infrastructure will support the transition highly. ▪ In the long term, the stranded asset issue of existing infrastructure is an unavoidable concern that requires proactive planning.
5. Highly significant	-

e. Continuation of investments in "old and dirty" technology



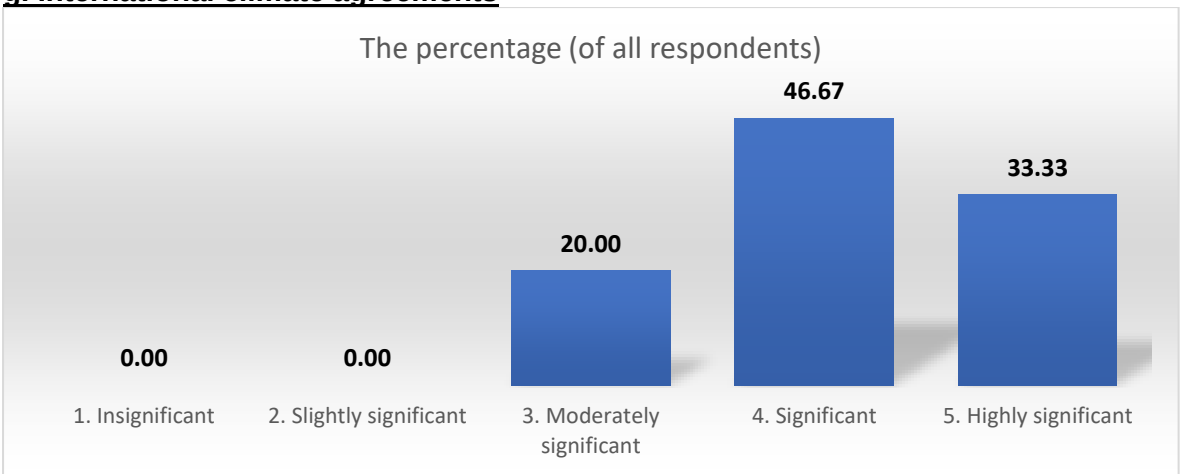
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	▪ We need to make a transformation.
3. Moderately significant	▪ Continued investment in "old and dirty" technologies may hinder the development of renewable power systems to a certain extent, but it is by no means the most significant barrier. As renewable power systems mature sufficiently, driven by external market demand and policy guidance, green electricity will eventually replace fossil-based electricity.
4. Significant	-
5. Highly significant	▪ Will lead to carbon still being emitted.

f. Domestic political constraints (policy and regulation)



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	-
5. Highly significant	▪ Monopoly in the supply and purchase of the electricity should be overcome. The government's uncertain policy will interfere the transformation. ▪ A net-zero power system differs significantly from the current fossil-based energy system. The development of a new energy power system requires systemic transformation across the power system, energy system, economic system, and social system. In this process, policy and regulatory support is indispensable. ▪ There is not political will and support from the top.

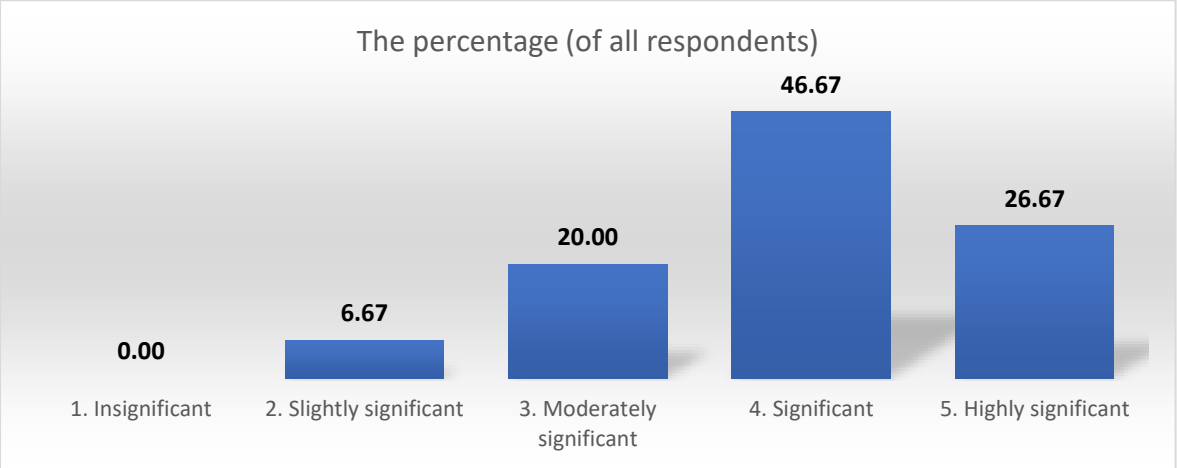
g. International climate agreements



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-

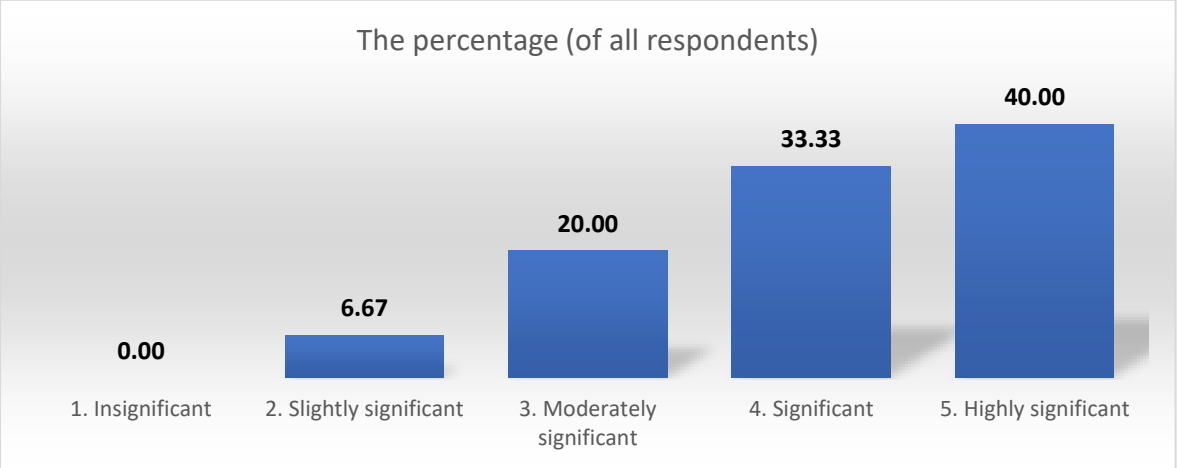
Level of significant	Comments
3. Moderately significant	-
4. Significant	▪ We need compulsory international regulation and efforts. ▪ International climate agreements can exert pressure on domestic policy shifts, but their implementation still relies on domestic policy enforcement. Therefore, I believe the importance of international climate agreements is less than that of domestic policies.
5. Highly significant	▪ International climate commitment will enable and push economies to become more low carbon. not a barrier

h. Public perceptions about climate change



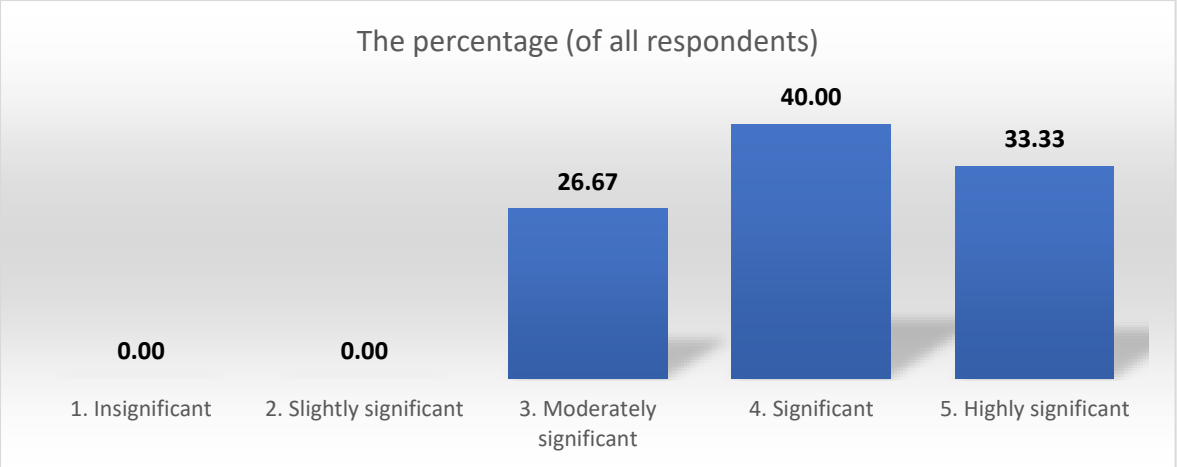
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	▪ The behavioral change will reduce the GHGs emissions from public sector.
5. Highly significant	▪ Public perceptions of climate change can influence the demand for numerous end-use energy consumptions, as well as the direction of domestic policy formulation, which is also crucial for the development of zero-carbon power systems. ▪ This is not a barrier but an enabler.

i. Insufficient capital to fund "new and clean" energy projects



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	-
5. Highly significant	▪ Without investment, the transition can't happen. ▪ The construction of new renewable and clean energy projects requires massive funding. If insufficient funding is available, it will have a significant impact on the development of zero-carbon power systems. ▪ This impacts the means of implementation of low carbon efforts.

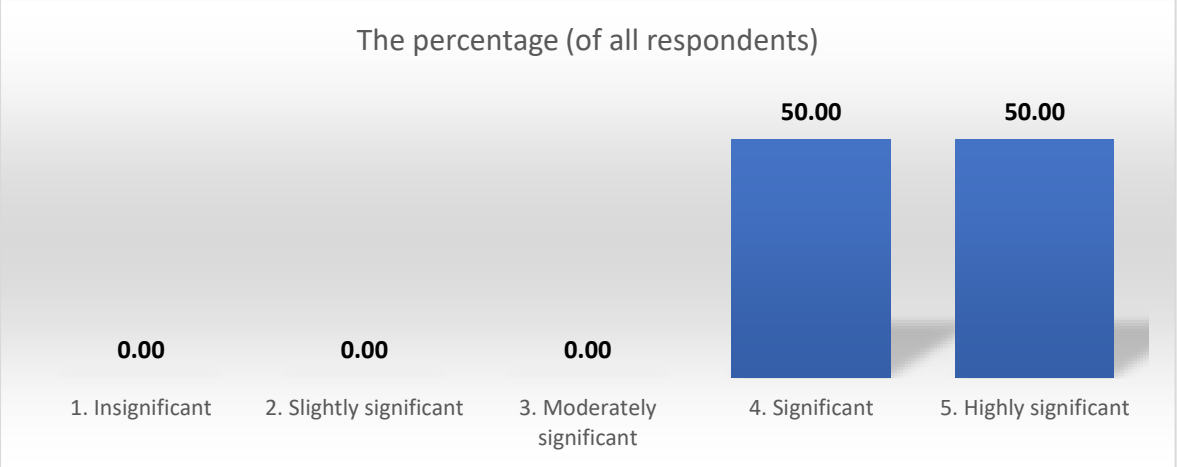
j. Geopolitics and energy security



Level of significant	Comments
1. Insignificant	▪
2. Slightly significant	▪
3. Moderately significant	▪ The regional collaboration is also important. ▪ Not knowledgeable to know the impacts.
4. Significant	▪
5. Highly significant	▪ I believe that energy security is the primary goal of energy

Level of significant	Comments
	development. Only by ensuring the security of energy supply can the zero-carbon power system be successfully implemented.

k. Others

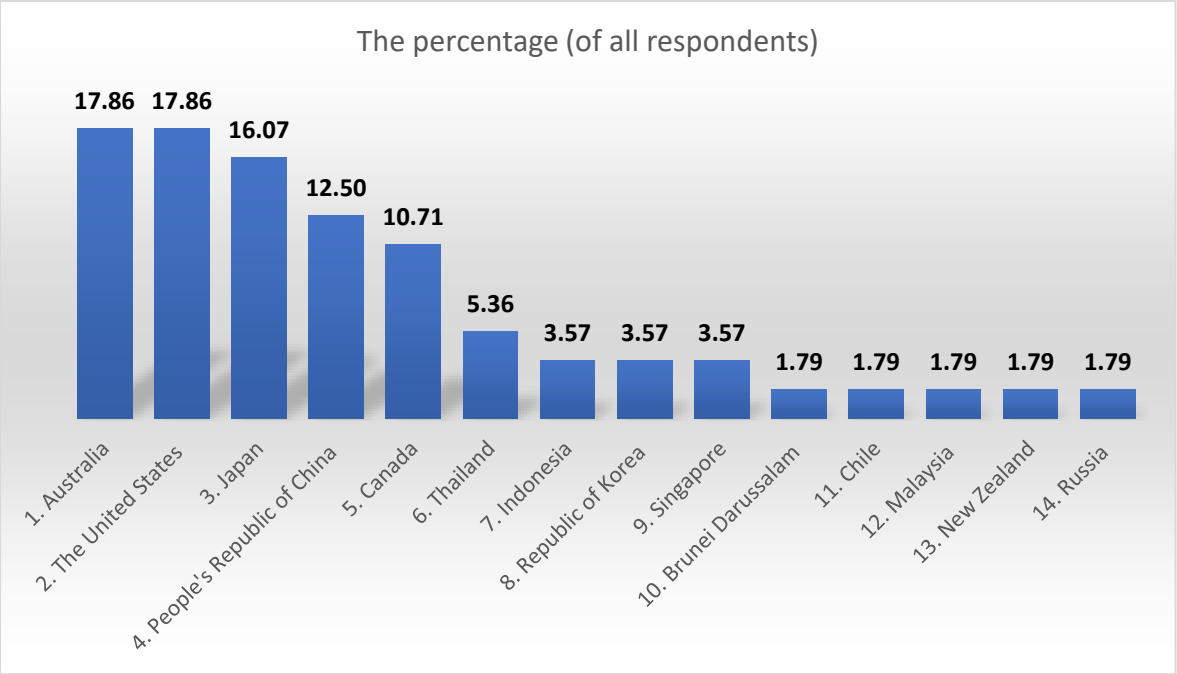


Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	[other: technology innovation] ▪ The technology innovation is very important.
5. Highly significant	[other: Better understanding of public finance] ▪ In Japan, it is necessary to increase better understanding of mechanism of "mobilization of public finance", "Japanese yen: money issues", and "Income of citizen/nation". If majority of people in Japan understand it well, government can invest the necessary amount for necessary infrastructure as a consequence of national democracy.

2.2 Hydrogen Economy

Hydrogen economy refers to an economy that relies on hydrogen as the commercial fuel to deliver a substantial fraction of a nation's energy services. It comprises of a linked network of chemical processes that produce hydrogen (e.g., electrolyzer), store hydrogen chemically or physically, and convert the stored hydrogen to electrical energy at the point of use. It is considered as the potentially key energy source to decarbonize energy systems in the hard-to-abate sectors such as cement, steel, and long-haul transport.

1. Based on your justification, please select up to five APEC economies that have the potential to become major producers/exporters of hydrogen energy.

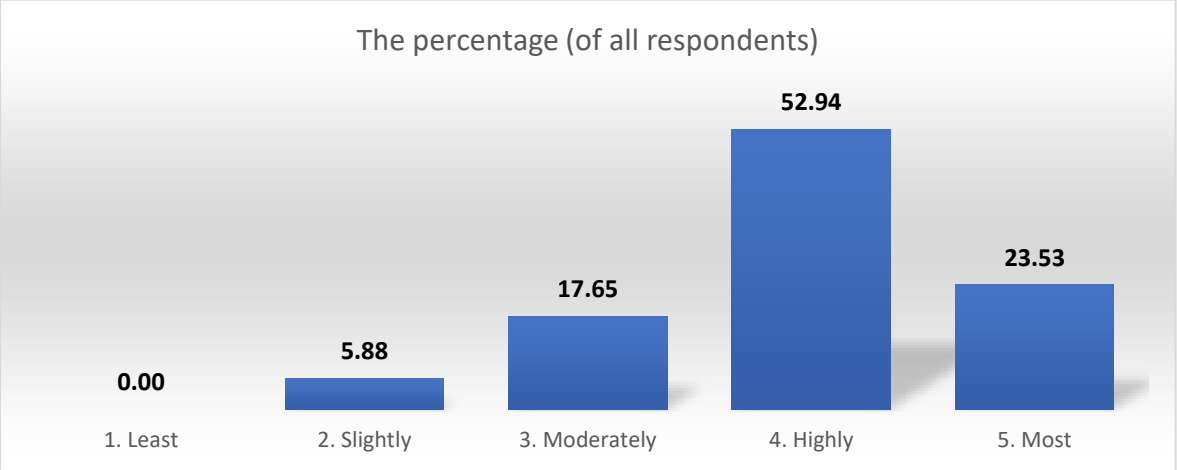


APEC economies	Comments
1. Australia	▪ Australia has abundant renewable energy resources and vast expanses of land, suitable for industrial-scale electrolytic hydrogen production. In addition, Australia locates in proximity to the Asian markets and has good trade partnerships. ▪ High technology level, good solar power, and large land. ▪ Australia has tremendous potential for the development of renewable energy and can become a major exporter of green hydrogen. ▪ Australia has abundant renewable resources, making it well-suited for hydrogen production through electrolysis. https://www.belfercenter.org/publication/geopolitics-renewable-hydrogen ▪ Australia has abundant renewable energy resources, including solar and wind, which can be used to produce green hydrogen through electrolysis. The country has been actively exploring opportunities to become a major exporter of hydrogen, particularly to Asian markets.

APEC economies	Comments
2. The United States	▪ The United States has strong innovative technology capabilities, coastal hydrogen hubs and ports. In addition, the US is a major consumer in hydrogen. ▪ High technology level, good solar power, and large land. ▪ The United States has tremendous potential for the development of renewable energy and advanced hydrogen technology, making it a major producer and consumer of hydrogen in the future. ▪ Various states and companies are investing in hydrogen projects; e.g., Bloom energy, etc.
3. Japan	▪ Hydrogen Supply chain. ▪ Hydrogen is the zero-carbon energy source Japan has identified for the future and has formulated a series of policies to support its development, making it a major importer of green hydrogen. ▪ Japan is one of the leading importers of energy, and it has a strong interest in hydrogen as a clean energy source. The Japanese government has been promoting the development of a "hydrogen society" and is exploring the importation of hydrogen, including green hydrogen produced from renewable sources.
4. People's Republic of China	▪ China has abundant renewable energy resources and is a major consumer in hydrogen. ▪ High technology level, good solar power, and large land. ▪ China has rapidly developed renewable energy and has a large demand for green hydrogen, making it a major producer and consumer of green hydrogen. ▪ China has been actively investing in the development of a hydrogen economy, with a focus on both domestic production and imports. The country aims to increase the share of hydrogen in its energy mix and has set targets for the deployment of fuel cell vehicles and hydrogen infrastructure.
5. Canada	▪ Canada has a large space for the development of renewable energy, rich resources, and advanced technology, and is close to the United States, making it a promising candidate to become an exporter of green hydrogen. ▪ Ref.: https://www.belfercenter.org/publication/geopolitics-renewable-hydrogen
6. Thailand	▪ Eager for the hydrogen economy, good solar power, and large land.
7. Indonesia	▪ Good solar power and large land. ▪ Not sure.
8. Republic of Korea	▪ South Korea has ambitious plans to establish itself as a major player in the hydrogen market. The government has announced initiatives to invest in hydrogen infrastructure, increase domestic production, and explore partnerships for hydrogen imports.
9. Singapore	▪ Singapore has been positioning itself as a hub for hydrogen trade and is exploring the potential of importing hydrogen to meet its energy needs. The country's

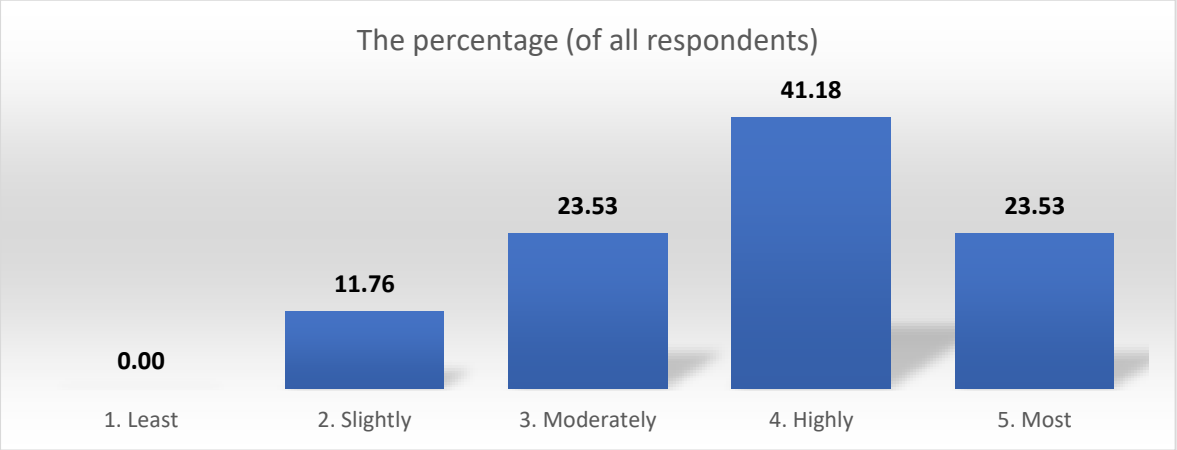
APEC economies	Comments
	strategic location and well-established infrastructure make it an attractive player in the emerging hydrogen market.
10. Brunei Darussalam	▪ Had a demo pilot project that successfully transported hydrogen to Japan for the 2020 Olympics.
11. Chile	-
12. Malaysia	▪ Not sure.
13. New Zealand	-
14. Russia	-

2. On a scale of 1 to 5, how desirable is it to increase the role of hydrogen energy in decarbonizing the hard-to-abate sectors in APEC?



Level of opinion	Comments
1. Least	-
2. Slightly	-
3. Moderately	-
4. Highly	▪ For steel and cement industry we need it very highly. ▪ Can reduce emissions and become cleaner.
5. Most	▪ Hydrogen energy is essential in decarbonizing the hard-to-abate sectors ▪ Hydrogen energy enables deep decarbonization in industries, complements sectors like heavy transportation, and serves as an ideal carrier to enhance energy system stability by providing seasonal storage. ▪ In my view, green hydrogen is an essential means for hard-to-reduce industries to achieve zero-carbon production, and it is crucial for the development of hard-to-reduce industries under zero-carbon constraints.

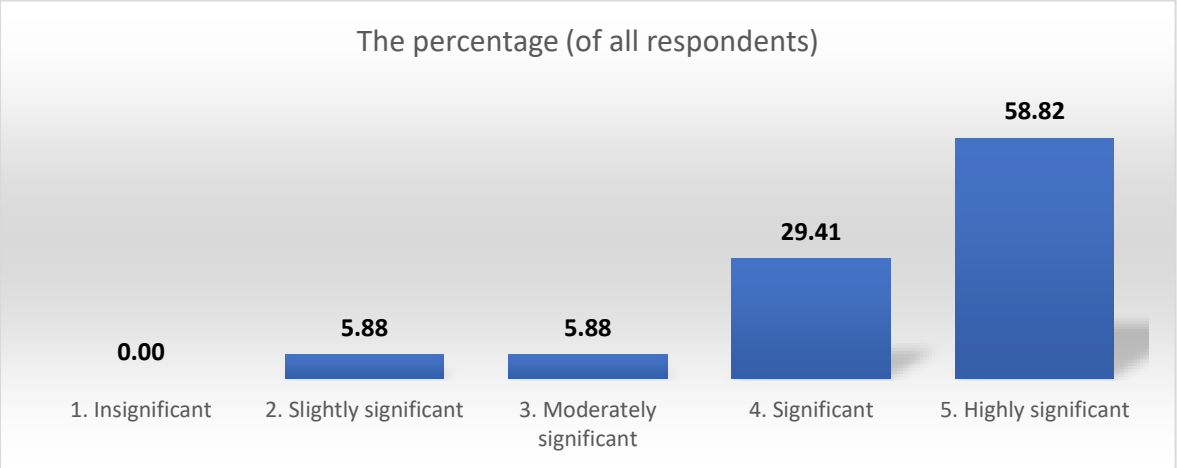
3. On a scale of 1 to 5, how confident are you (i.e., what is the probability) of increasing the role of hydrogen energy to decarbonize the hard-to-abate sectors in APEC?



Level of confident	Comments
1. Least	-
2. Slightly	▪ Not sure.
3. Moderately	-
4. Highly	▪ Some economies have good solar power and large land.
5. Most	▪ Hydrogen energy is essential in decarbonizing the hard-to-abate sectors. ▪ In my view, the hydrogen industry has developed rapidly in recent years, with significant technological advancements, giving me great confidence in the use of hydrogen in hard-to-reduce industries in the future.

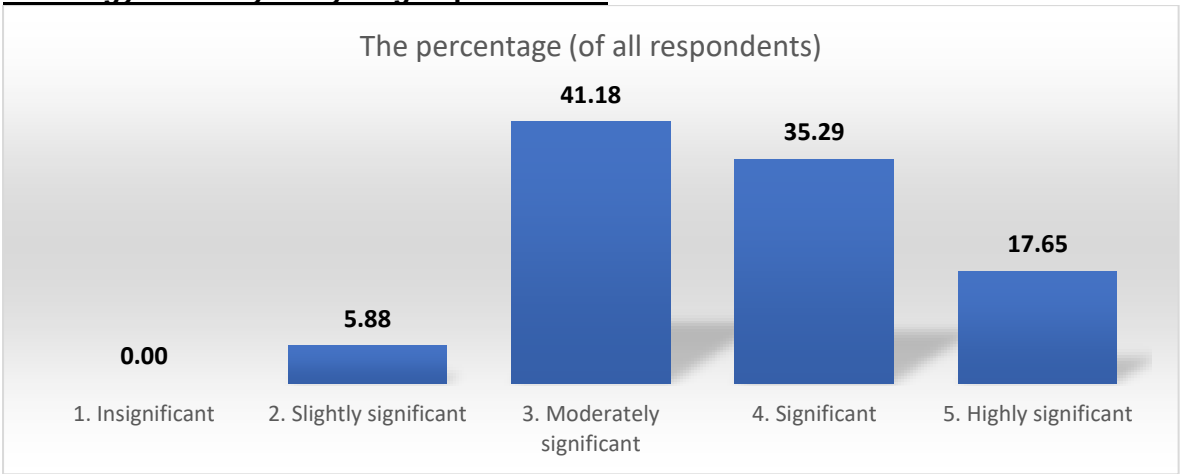
4. Based on your justification, how significant are the following barriers to the development of a hydrogen economy across the APEC?

a. Hydrogen production costs



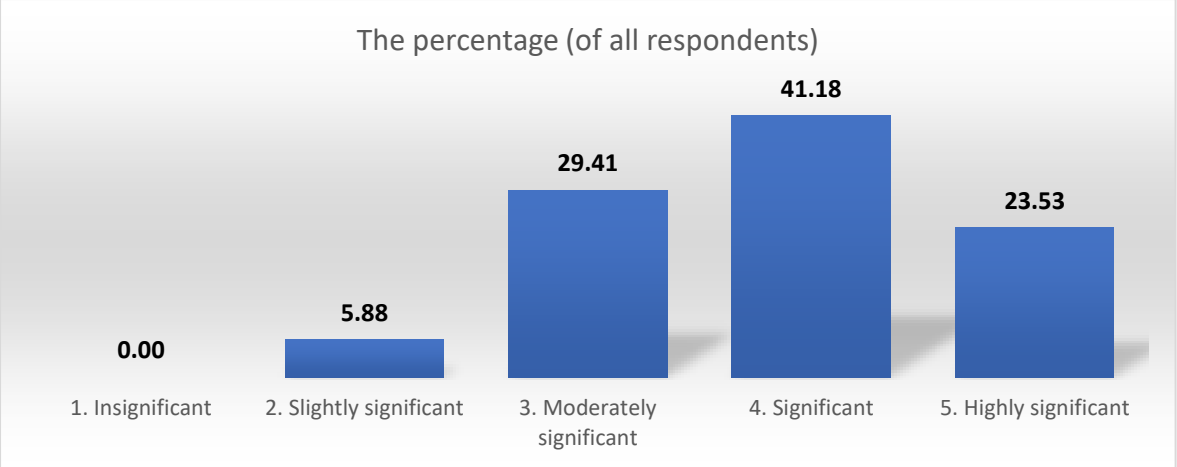
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	▪ Not sure.
3. Moderately significant	-
4. Significant	-
5. Highly significant	▪ Clean hydrogen production cost is a main barrier for the development of hydrogen economy. ▪ The cost is the highest concern for the deployment. ▪ The cost of hydrogen production is the most significant factor hindering the widespread adoption of hydrogen. Without economic viability, the large-scale utilization of green hydrogen will also be challenging.

b. Energy intensity of hydrogen production



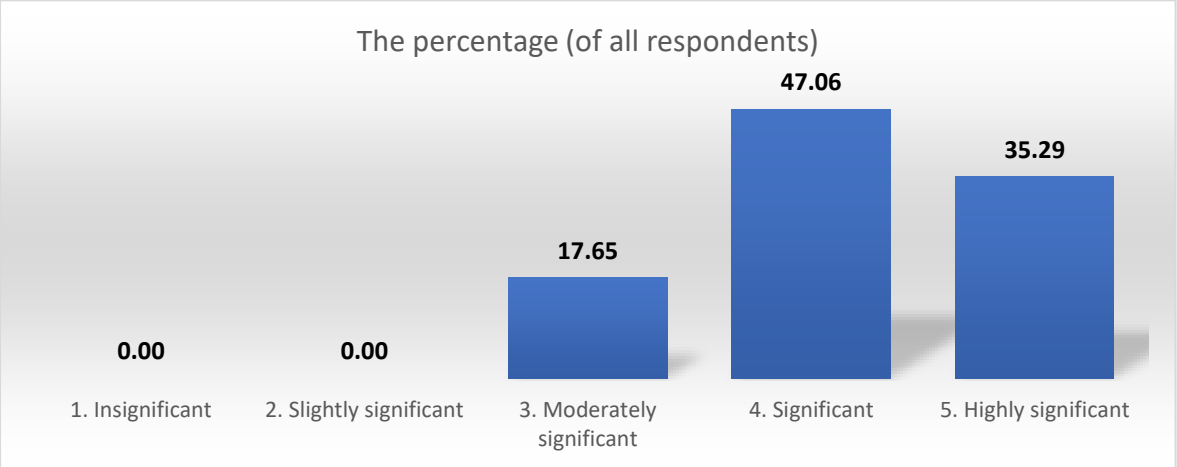
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ The energy intensity of hydrogen production is an important factor affecting the economic feasibility of green hydrogen, but since the technology is still in the development process, the energy intensity of the same generation of technology is not significantly different, so it is considered important, but not the most important. ▪ Not sure.
4. Significant	▪ Energy intensity of hydrogen production affects its cost.
5. Highly significant	▪ It is directly related with the cost.

c. Technical challenges associated with storing and transporting hydrogen



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ Storing and transporting hydrogen in long distance and large volume has great technical challenges, but regional hydrogen distribution is less a concern.
4. Significant	▪ Not sure.
5. Highly significant	▪ It will highly affect the deployment. ▪ The storage and transportation technologies of hydrogen are the key technologies that limit the large-scale and long-distance use of hydrogen, and they are related to the safety and economic feasibility of the hydrogen economy, so I believe they are extremely important.

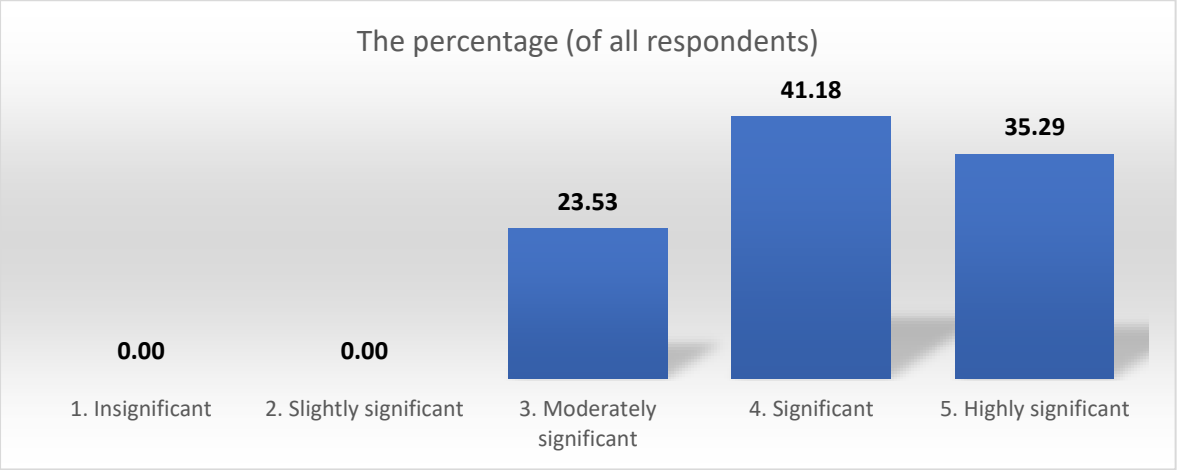
d. Establishing a hydrogen infrastructure (production facilities, distribution pipelines, and refueling stations)



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ For some end uses, such as hydrogen fuel cell vehicles,

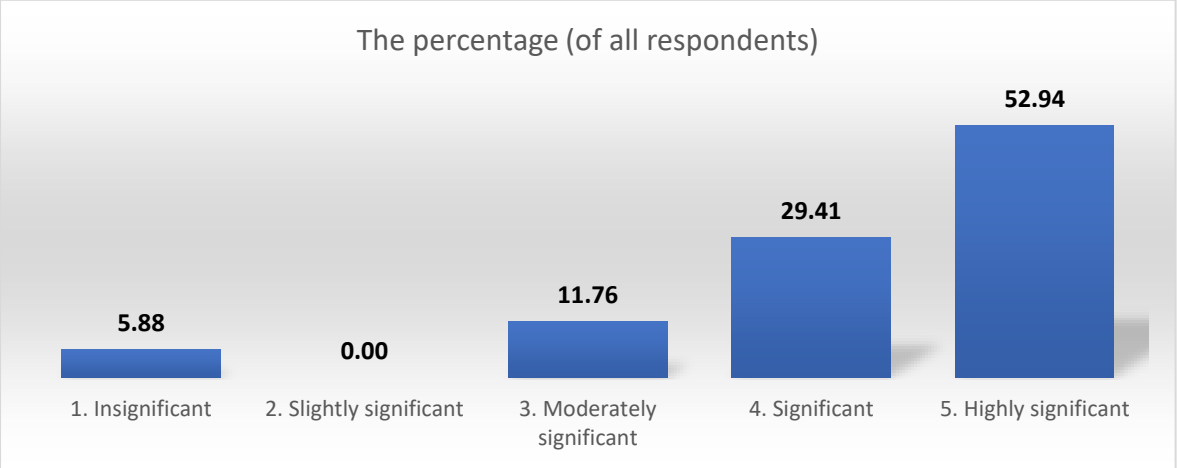
Level of significant	Comments
	hydrogen infrastructure is highly significant, but for others, such as industrial uses, infrastructure is not the main barrier.
4. Significant	▪ Not sure.
5. Highly significant	▪ It is very important to deploy the hydrogen energy. ▪ The development of hydrogen infrastructure determines the scope and scale of hydrogen utilization, and it is also extremely important.

e. Standardization and safety of a hydrogen economy



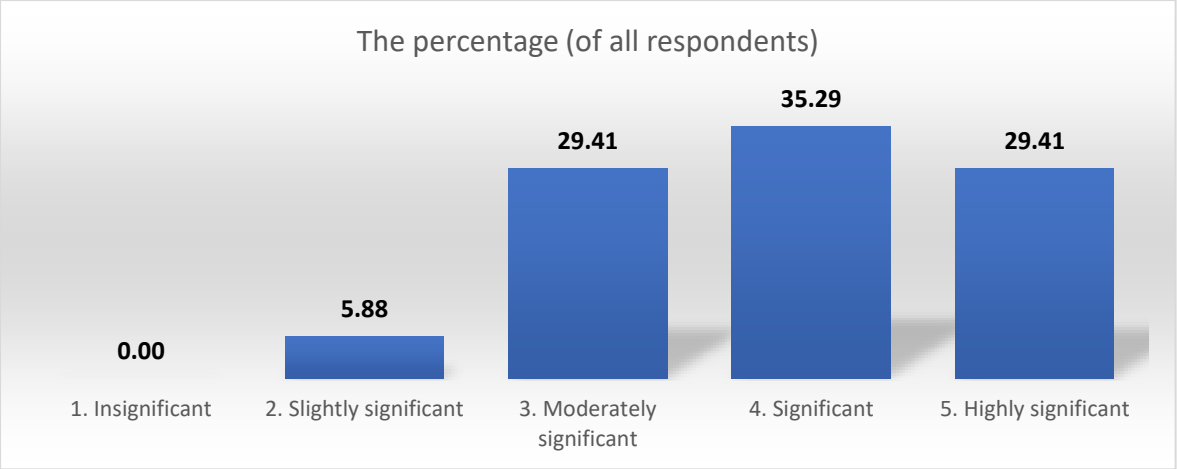
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	▪ It will facilitate the deployment of hydrogen energy. ▪ Compared to hydrogen technology and hydrogen infrastructure, the standards and safety of the hydrogen economy are important, but not the most important. These may affect the initial development of the hydrogen economy, but if the technology is feasible and economically reasonable, the standards and safety issues of the hydrogen economy can be adjusted quickly. ▪ Not sure.
5. Highly significant	▪ Standardization and safety of a hydrogen economy is necessary for the development of hydrogen economy.

f. Production of hydrogen from low-carbon or renewable sources



Level of significant	Comments
1. Insignificant	▪ No barrier probably.
2. Slightly significant	-
3. Moderately significant	-
4. Significant	-
5. Highly significant	▪ Only low-carbon or zero carbon hydrogen can contribute to the decarbonizing of the economy, but its production capacity is very small at this moment. ▪ We need to implement carbon neutrality through REs. ▪ Hydrogen produced from low-carbon or renewable energy sources, also known as green hydrogen, is the core prerequisite for the development of the hydrogen economy.

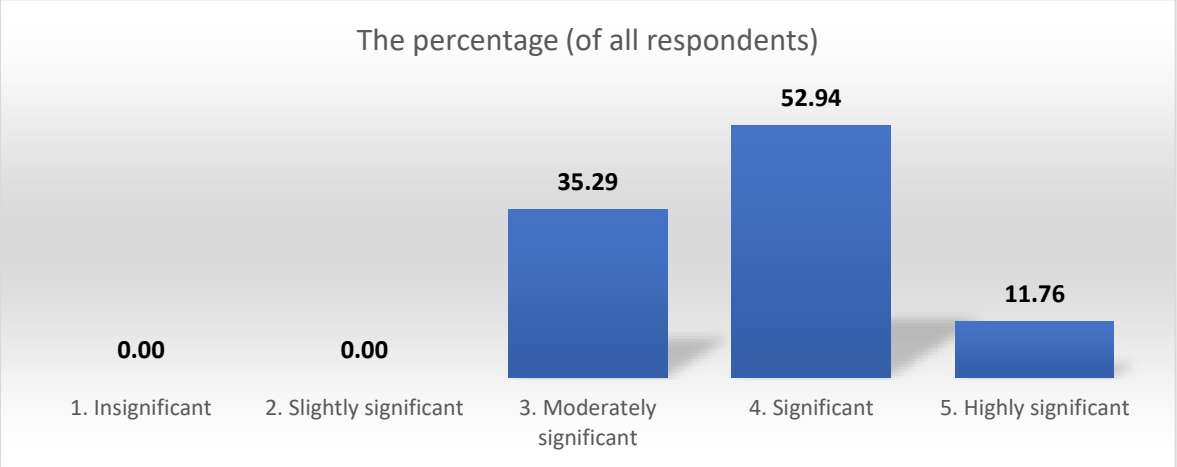
g. Domestic political constraints (policy and regulation)



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ Not sure.
4. Significant	▪ Policy and regulation should be revised so that hydrogen can be used as an energy carrier.
5. Highly significant	▪ It affects the investment and innovation.

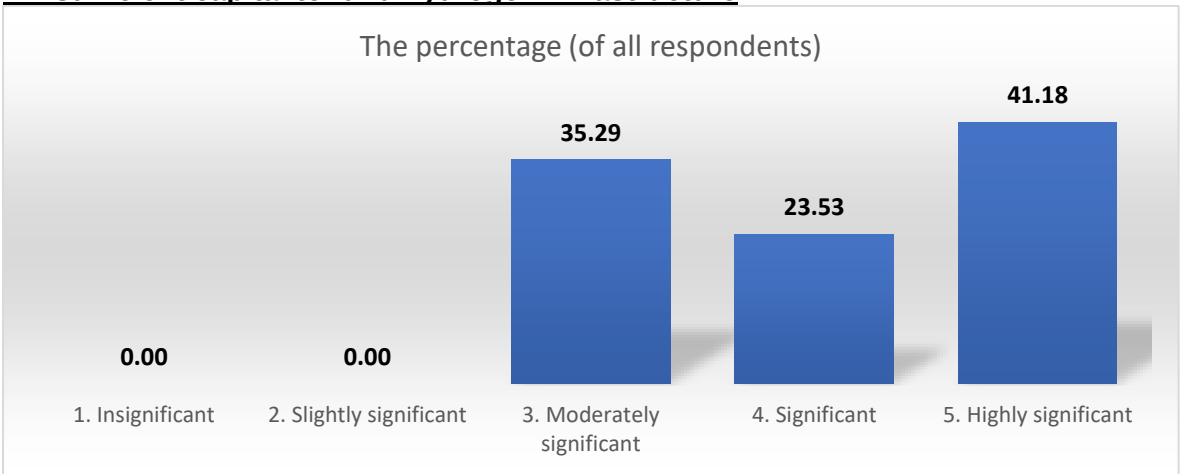
Level of significant	Comments
	▪ During the initial stage of the development of the hydrogen economy, it will still face many issues such as technology, economic feasibility, and safety, which require the support of domestic policies. This is crucial for the smooth development of the hydrogen economy.

h. Public perceptions and acceptance of hydrogen technology



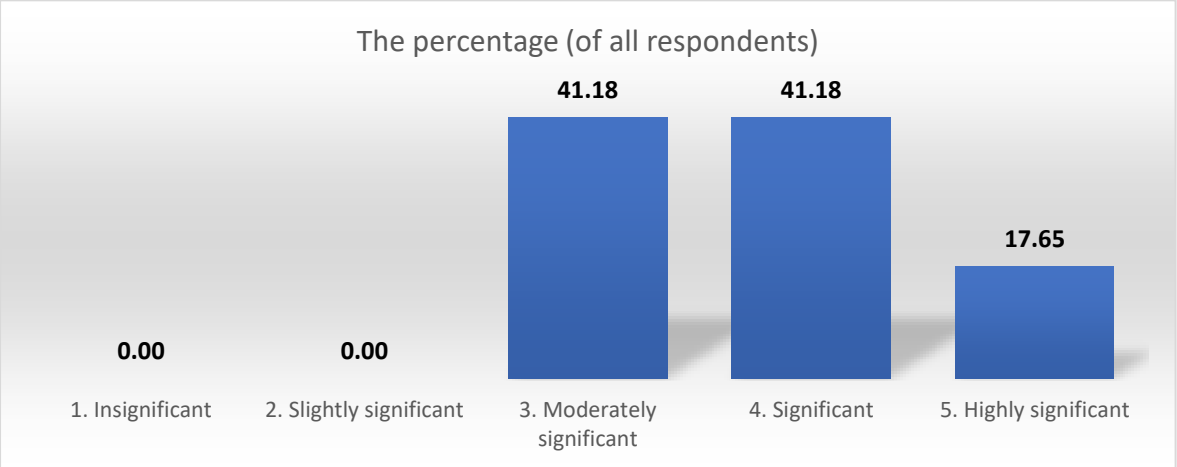
Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ I believe that hydrogen is more oriented towards industries or businesses, and the acceptance of the hydrogen economy by the public has a certain impact on the development of the hydrogen economy, but it is not the most important influencing factor. ▪ Not sure.
4. Significant	▪ Public perceptions and acceptance is important for the deployment of hydrogen technology in large scales. ▪ The awareness of the public will affect the deployment of hydrogen energy.
5. Highly significant	-

i. Insufficient capital to fund hydrogen infrastructure



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	▪ For some end uses, such as hydrogen fuel cell vehicles, hydrogen infrastructure is highly significant, but for others, such as industrial uses, infrastructure is not the main barrier.
4. Significant	▪ More funding less barrier.
5. Highly significant	▪ Without investment, there will be no deployment. ▪ I believe that the hydrogen society needs to reshape the current energy infrastructure, which will require an enormous amount of funding. If the funding is insufficient, it will greatly hinder the development of the hydrogen economy.

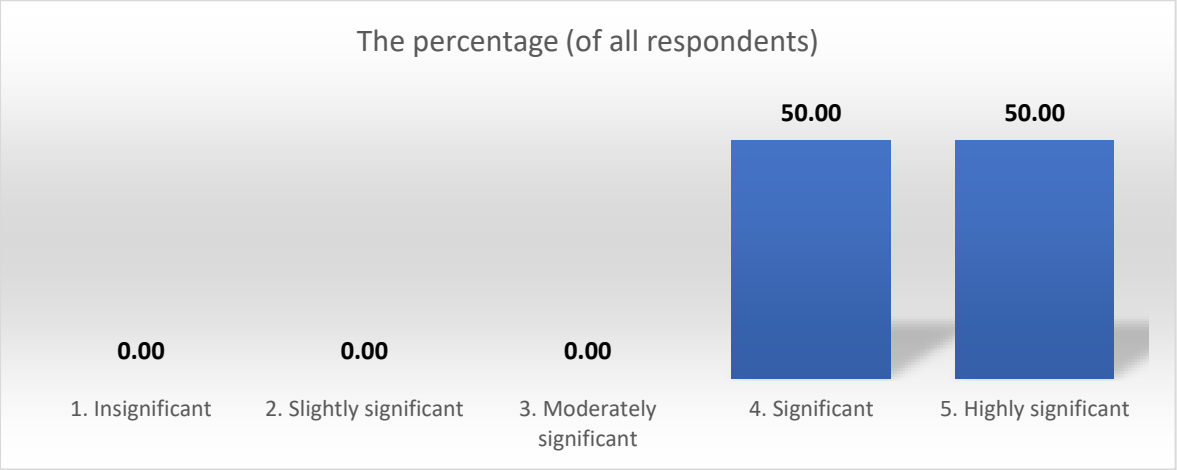
j. Geopolitics and energy security



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	▪ Geopolitics and energy security may reshape the hydrogen industry, but at this moment, it is less a concern.

Level of significant	Comments
3. Moderately significant	▪ Geopolitics and energy security may reshape the hydrogen industry, but at this moment, it is less a concern. ▪ Not sure.
4. Significant	▪ I believe that due to the widespread distribution of renewable energy, the production of green hydrogen will also be decentralized, and its impact on geopolitics and energy security will be relatively small.
5. Highly significant	▪ The hydrogen economy (production, distribution, storage and utilization) are highly dependent on geopolitics.

k. Others



Level of significant	Comments
1. Insignificant	-
2. Slightly significant	-
3. Moderately significant	-
4. Significant	[other: Green hydrogen certification] ▪ Certificates for hydrogen and its derivatives are essential for hydrogen trade across different countries to recognize the value of green or low carbon hydrogen.
5. Highly significant	[other: Global value chain] ▪ There should be global supply and demand for the hydrogen economy.

Appendix

Issue 2.1- 2. On a scale of 1 to 5, how significant will the following technologies be in the decarbonization of your economy by 2050?

Technologies be in the decarbonization of your economy by 2050	Level of Significant				
	Insignificant	Slightly significant	Moderately significant	Significant	Highly significant
a. Electrification with renewable energies	0.00%	5.88%	0.00%	23.53%	70.59%
b. Electrification with fossil fuel and CCS	11.76%	11.76%	41.18%	11.76%	23.53%
c. Electrification with nuclear power	11.76%	17.65%	35.29%	29.41%	5.88%
d. Fossil-based hydrogen economy and CCS	5.88%	29.41%	29.41%	29.41%	5.88%

Issue 2.1- 4. On a scale of 1 to 5, how significant will the following technologies be in the electricity supply system in your economy to achieve net-zero emissions?

Technologies be in the electricity supply system to achieve net-zero emissions	Level of Significant				
	Least	Slightly	Moderately	Highly	Most
a. Solar power	0.00%	0.00%	13.33%	33.33%	53.33%
b. Wind power	6.67%	13.33%	26.67%	40.00%	13.33%
c. Hydro power	6.67%	13.33%	20.00%	33.33%	26.67%
d. Nuclear power	40.00%	20.00%	20.00%	20.00%	0.00%
e. Bioenergy	6.67%	20.00%	20.00%	46.67%	6.67%
f. Fossil-based electricity with carbon capture and storage	13.33%	13.33%	20.00%	40.00%	13.33%
g. Lithium battery for electricity storage	13.33%	0.00%	20.00%	33.33%	40.00%
h. Other chemical electricity storage	6.67%	26.67%	20.00%	33.33%	13.33%
i. Decentralized prosumer-centric peer-to-peer electricity trading system	6.67%	20.00%	26.67%	40.00%	6.67%
j. Others	0.00%	50.00% (Tidal energy)	0.00%	50.00% (hydrogen)	0.00%

Issue 2.1- 5. Based on your justification, how significant are the following barriers to achieving low carbon electricity systems across APEC economies?

Barriers to achieving low carbon electricity systems across APEC economies	Level of Significant				
	Insignificant	Slightly significant	Moderately significant	Significant	Highly significant
a. Intermittency of renewable energy sources	0.00%	13.33%	13.33%	26.67%	46.67%
b. Insufficient energy storage capacities	0.00%	6.67%	33.33%	26.67%	33.33%
c. Modernization of grid infrastructure	0.00%	0.00%	13.33%	53.33%	33.33%
d. Inadequacy of existing infrastructure (i.e., risks of stranded assets)	6.67%	6.67%	40.00%	40.00%	6.67%
e. Continuation of investments in "old and dirty" technology	0.00%	6.67%	40.00%	33.33%	20.00%
f. Domestic political constraints (policy and regulation)	0.00%	0.00%	13.33%	53.33%	33.33%
g. International climate agreements	0.00%	0.00%	20.00%	46.67%	33.33%
h. Public perceptions about climate change	0.00%	6.67%	20.00%	46.67%	26.67%
i. Insufficient capital to fund "new and clean" energy projects	0.00%	6.67%	20.00%	33.33%	40.00%
j. Geopolitics and energy security	0.00%	0.00%	26.67%	40.00%	33.33%
k. Others	0.00%	0.00%	0.00%	50.00% (technology innovation)	50.00% (Better understanding of public finance)

Issue 2.2- 4. Based on your justification, how significant are the following barriers to the development of a hydrogen economy across the APEC?

Barriers to the development of a hydrogen economy across the APEC	Level of Significant				
	Insignificant	Slightly significant	Moderately significant	Significant	Highly significant
a. Hydrogen production costs	0.00%	5.88%	5.88%	29.41%	58.82%
b. Energy intensity of hydrogen production	0.00%	5.88%	41.18%	35.29%	17.65%
c. Technical challenges associated with storing and transporting hydrogen	0.00%	5.88%	29.41%	41.18%	23.53%
d. Establishing a hydrogen infrastructure (production facilities, distribution pipelines,	0.00%	0.00%	17.65%	47.06%	35.29%

Barriers to the development of a hydrogen economy across the APEC	Level of Significant				
	Insignificant	Slightly significant	Moderately significant	Significant	Highly significant
and refueling stations)					
e. Standardization and safety of a hydrogen economy	0.00 %	0.00 %	23.53%	41.18%	35.29%
f. Production of hydrogen from low-carbon or renewable sources	5.88 %	0.00 %	11.76%	29.41%	52.94%
g. Domestic political constraints (policy and regulation)	0.00 %	5.88 %	29.41%	35.29%	29.41%
h. Public perceptions and acceptance of hydrogen technology	0.00 %	0.00 %	35.29%	52.94%	11.76%
i. Insufficient capital to fund hydrogen infrastructure	0.00 %	0.00 %	35.29%	17.65%	47.06%
j. Geopolitics and energy security	0.00 %	0.00 %	41.18%	41.18%	17.65%
k. Others	0.00 %	0.00 %	0.00 %	50.00% (Green hydrogen certification)	50.00% (Global value chain)