

## 1<sup>st</sup> Symposium on Ammonia Energy – Opening Remarks

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Ammonia is increasingly recognized as an energy carrier that will play a critical role in the coming years. Ammonia production is the largest hydrogen market today and it will remain a key market in the future. Renewable ammonia is a key component of the hydrogen economy. On 19 May IRENA released its “Innovation Outlook Renewable Ammonia”, prepared in cooperation with the Ammonia Energy Association.

Ammonia is an essential global commodity. Synthetic nitrogen fertilizer is produced from ammonia. Nearly 200 Mt of ammonia are produced every year. The fertilizing sector is the largest ammonia market today. Various types of nitrogen fertilizer exist such as ammonium nitrate and urea. The energy content of ammonia is roughly half that of oil products.

There is increasing interest in ammonia as energy carrier: as CO<sub>2</sub> free fuel for ocean going vessels, as fuel for power plant or as hydrogen energy carrier. Ammonia also presents a unique platform for hydrogen storage and renewable energy delivery. As the recognition of the molecule increases, ammonia combustion research is expanding in the academic community and across governmental institutions. Also, industrial scale projects are emerging.

An increasing number of ammonia conferences and symposia are currently taking place worldwide. These efforts are supported by organizations and associations willing to reach a zero-carbon economy. This includes IRENA and its 168 member countries.

### **Energy conversion efficiency and economic viability**

Today the majority of ammonia is produced from natural gas. A typical gas-based ammonia plant is 60% energy efficient. Global ammonia production today accounts for around 2% (8.6 EJ) of total final energy consumption. Direct emissions from ammonia production currently amount to 450 Mt CO<sub>2</sub>.

A shift to Renewable ammonia – produced from green hydrogen that in turn is produced from renewable power- can eliminate the process emissions. Also, this would decouple ammonia production from natural gas pricing.

Ammonia prices are volatile. The present ammonia spot price is very high, above 1000 USD/t.

Today’s cost of renewable ammonia is USD 720/t at locations with good solar and wind resources. So, this cost is already below today’s ammonia spot price, and it is expected to halve in the years to come, as the cost of green hydrogen continues to fall.

Modern renewable ammonia synthesis from low temperature electrolysis (alkaline or PEM) typically consumes about 36 GJ/t ammonia, e.g., around 50% energy conversion efficiency. This is expected to decrease to 26 GJ/t ammonia in the long term.

### **Prospects for international trade**

New IRENA model analyses suggest that a quarter to a third of all hydrogen may be traded internationally, half via pipeline and half by ship. Ammonia seems the most attractive shipping option with up to 100 Mt of ammonia shipped in 2050 according to recent IRENA analyses. Of this traded ammonia 20% will be reconverted to hydrogen. Process catalyst improvements that enhance the conversion energy efficiency constitute an important area of research.

Significant experience exists with regards to ammonia shipping: World trade in ammonia amounted to around 15 Mt or 10% of total production in 2020. Renewable ammonia opens up the opportunity to tap into remote low-cost renewable energy potentials.

### **Future demand growth 2050**

Demand side innovations create new ammonia market opportunities. A potential 550 Mt ammonia shipping fuel market is under development. Ammonia can be stored as a liquid below -33°C. Ammonia is difficult to burn, so specialised internal combustion engines are currently being developed. These are expected to be available in 2024. Ammonia fueled ships are currently being demonstrated. LNG ships are being built with ammonia retrofit option. It is unclear at this moment if ammonia will fare better than competing fuel options such as methanol.

Ammonia can also be used as fuel in power plants. Japan aims to import 3 Mt ammonia fuel by 2030, growing to 30 Mt by 2050. While ammonia fuel is expensive, the ability to import ammonia and the capacity to store ammonia seasonally may result in a viable pathway.

The IRENA 1.5°C scenario assumes a 688 million tonne (Mt) ammonia market in 2050, nearly quadrupling today's market. In this scenario, 566 million tons of new renewable ammonia production must come onstream. The production of this ammonia would constitute nearly a fifth of the total global green hydrogen market in 2050.

### **The need for sector coupling 2030**

The capacity of announced renewable ammonia plants currently totals 15 Mt by 2030 (about 8% of the current ammonia market). The full project pipeline is nearly five times that size. So, the development of renewable ammonia will have major impacts on the global green hydrogen development in the coming years. Also, the implications for renewable power capacity are significant.

In conclusion, renewable ammonia is a key early market opportunity for green hydrogen and renewable ammonia that can become a key commodity.

Along those lines, I am glad to inaugurate the 1st Symposium on Ammonia Energy, which I believe will be a unique opportunity to enable scientist and technicians from all corners of the globe to discuss novel findings and future trends for the production, storage, distribution and use of ammonia as an enabler of a green world.