Energy Transitions Commission

Key messages Power report

A net zero GHG emissions economy by mid-century is technically and economically feasible, and is built on abundant, cheap zero-carbon electricity. By 2050, electricity use could grow 3.5-5 times to reach as much as 130,000 TWh. By 2050, electricity could represent between 60-70% of final energy demand, versus 20% today. **Transitioning to electricity as the main source of final energy represents the cheapest and most efficient way to decarbonise the economy.**

Rapidly falling costs of renewables and storage solutions make it possible to achieve the massive expansion required of clean power systems at low-cost. All-in system generation costs of high variable renewable power systems in 2030 will likely be no higher than today. However, maximizing low-cost clean electricity relies on countries committing in advance to decarbonisation strategies.

Wind and solar generation must grow from today's 10% of total electricity generation to around 40% by 2030, and over 75% by 2050. Annual wind and solar installations must grow 5-7 times by 2030, and over 10 times by 2050. While this is undoubtedly within our reach, it will require a significant mobilisation of resources and clear national strategies for decarbonisation**.** Growth in wind and solar must be accompanied by the parallel deployment of other zero-carbon generation, flexibility, storage and networks to deliver zero-carbon power systems at scale.

Investments in clean power generation, primarily wind and solar, will represent the vast majority (around 80%) of total investments required to achieve a net-zero economy. Total global investments of around $2.5 trillion per annum will be needed in clean power generation ($1.5-1.6 trillion) and in supporting transmission and distribution networks ($1 trillion). While this is a large number, the scale is clearly manageable in the current macroeconomic environment, and represents less than 1.5% of global GDP.

Overall, achieving massive electrification and early power decarbonisation – ahead of economy-wide decarbonisation - must be at the heart of all countries' paths to net zero. Developed and developing countries should adopt strategies to achieve grid emissions intensity below 30gCO_2/kWh by the mid-2030s and mid-2040s respectively.

Governments, investors, corporates and civil society need to work together to act today to overcome barriers to scaling massive clean electrification. This will require 6 critical actions in the 2020s:

1. **Clear medium-term <u>targets</u> embedded in a strategic vision for economy decarbonisation**
   This involves setting quantitative targets for zero-carbon electricity, such as wind & solar capacity, and targets for the phase out of fossil fuel generation. This should also entail bans on fossil technologies, such as internal combustion engine vehicles.

2. **Appropriate incentives for renewables <u>deployment</u> at scale, including power market design**
   Appropriate power market design will be critical to reaching these targets. This includes the continued role of long-term contracts for zero-carbon generation and storage, with auction pipelines sufficient to meet overarching targets – as well as

reforms to short-term, capacity, and ancillary services markets. Further actions include the removal of all remaining fossil fuel subsidies, setting incentives and subsidies for electrification (where needed, e.g. heat pumps) and standards and regulations, such as setting quotas for electric vehicle sales.

3. **Building the infrastructure and capabilities required for simultaneous mass electrification and power system decarbonisation**
   Digitalised and expanded networks are essential to building the clean power systems of the future. We must establish regulatory frameworks to enable anticipatory investment in power networks, to build of networks ahead of need and reduce bottlenecks. We must also build the infrastructure necessary for electrification (e.g. electric vehicle charging stations, as well as retrofits on buildings).
4. **Appropriate planning and permitting to speed up implementation**
   Local and national government will need to streamline planning, permitting and land acquisition processes. Planning will also require an integrated vision for power system designs.
5. **Unlocking financial flows, especially for developing countries**
   We must implement instruments to scale investment in developing countries – such as blended or concessional finance, securitization of assets – and roll out mechanisms to phase out fossil – via PPA modification and/or debt restructuring.
6. **Developing the technologies and business models of the future, investing in R&D**
   This will require public and private focus on R&D in areas such as long-term energy storage (e.g. hydrogen), continuing VRE cost declines and increasing their range (e.g. floating wind), and continue to drive cost declines in key electrification technologies (e.g. lithium-ion batteries).

Key messages Hydrogen report

With clean electrification at the heart of a zero-carbon economy, **clean hydrogen will play a major role in decarbonising sectors that are difficult or impossible to electrify**, in particular heavy industry, long-distance transport and long-term energy storage. A net-zero GHG emissions economy by mid-century will **likely need to use about 500 to 800 Mt of clean hydrogen per annum, a 5-7 fold increase compared to today.** By 2050, clean hydrogen (and its derivatives) could represent 15-20% of the final energy demand.

Hydrogen demand will primarily stem from four areas:

1. **Existing hydrogen uses** which must be made zero-carbon – like fertiliser production and refining.
2. **New large long-term uses**, which will grow slowly as technologies are not always commercially-ready yet – for instance, hydrogen-based steel reduction or hydrogen-based fuels production for shipping and aviation.
3. **Potential transitional opportunities**, which may enable emission reductions in the short term, but will need to eventually be phased out because they cannot reach zero-carbon – in particular hydrogen blending in coal-fired processes and gas networks.

4. Other possible uses, where the relative costs and advantages of hydrogen versus other decarbonisation options are **still unclear** – for instance in trucking where the role of fuel-cell vehicles versus electric trucks will depend on how much progress is achieved in battery technologies.

Green hydrogen, produced via the electrolysis of water, is likely to be the major route in the long-term due to falling renewable electricity and electrolyser equipment costs. However, **blue hydrogen**, **produced from natural gas with carbon capture (with 90%+ capture rates) and low methane leakage (<0.05%), will play an important role in transition** and in some specific low-cost gas locations. By 2050, about 85% of hydrogen production will likely come from the green route.

Clean hydrogen could be as cheap as grey hydrogen in some regions in the 2020s. To achieve this goal, green hydrogen production and use should grow fast enough, reaching 50 GW (c. 5 Mt) of electrolyser capacity. However, using clean hydrogen in end-use applications will often continue imposing a **"green cost premium"** vs. current high-carbon technologies – public policy is therefore essential to drive hydrogen uptake at the right pace.

There are no inherent barriers to ramping up clean hydrogen production to 800 Mt per annum, but strategic planning is required to avoid any bottlenecks:

- **For green hydrogen**, natural resources are not a limiting factor, but huge increases in zero-carbon electricity supply are required (electricity demand for electrolysis could be 30,000 TWh in 2050 – similar to today's total power consumption and ca. 25% of total power demand by then);
- **For blue hydrogen**, public-private collaboration should accelerate historically long project lead times, build-up of shared CO_2 infrastructure and overcome public resistance to CCS.

The development of the hydrogen economy will create significant transport and storage needs. Transport and storage systems will need to be developed to connect favourable production and storage sites with demand sites, and will take a variety of forms (pipeline, shipping), reflecting local circumstances and technology cost developments. Intermittent green hydrogen production and the use of hydrogen for power balancing will create significant storage needs (estimates suggest 15%+ of total hydrogen consumption). As cheap clean hydrogen production becomes feasible across the globe, international trade may be limited to specific circumstances.

Total investments required to ramp-up hydrogen production could amount to almost $15 trillion between now and 2050. Annual investment needs would peak in the late 2030s at around **$800 billion per annum.** Around 85% relates to the increase in electricity generation for green hydrogen production, and 5% to investment in electrolyser capacity.

Public policy needs to focus on pulling forward clean hydrogen demand in the 2020s to drive production volumes up (reaching **50 Mt**) and clean hydrogen costs down (**well below $2/kg**):

- Driving the rapid decarbonisation of hydrogen production for **already existing uses**, through carbon pricing, carbon-intensity regulations and contracts for difference;
- Accelerating rapid technology development, piloting and early adoption of hydrogen in other key sectors with **lower levels of technology readiness but large potential demand**, like steel, shipping and synthetic aviation fuels.

The development of hydrogen clusters is critical during this first decade, as it enables the simultaneous development of hydrogen production, storage, transport and end-use, de-risking investments for all players involved. They will likely develop around ports, cities and existing refinery, fertiliser and steel sites. The biggest cost driver in hydrogen clusters will be clean hydrogen production, especially zero-carbon electricity generation – policy and industry action should therefore focus on providing low-cost capital for hydrogen CAPEX (e.g., via blended finance mechanisms) and reducing the electricity bill (e.g., waiving grid tariffs).

Governments, investors, corporates and civil society need to work together today to drive the take-off of a hydrogen economy. These efforts will need to focus on 6 priorities:

1. Carbon pricing to create broad incentives for decarbonisation of existing hydrogen supply and of new use cases
2. Sector-specific policies to create demand (e.g. mandates, public procurement) and financial support mechanisms for investment and OPEX (e.g. contracts for difference) to overcome the 'green cost premium' challenge of clean hydrogen
3. Targets for the development of large-scale electrolysis manufacturing and installation
4. R&D and deployment support for less mature technologies, especially for hydrogen use in heavy industry and synthetic fuels production
5. Development of hydrogen clusters
6. Rules and standards on safety, purity and clean hydrogen certification