

Decarbonising the energy trade



The Lux Research team has released an analysis of how future global energy networks will evolve as a result of the world moving away from the intensive use of carbon-based fossil fuels and towards more renewable and cleaner energy sources. The report's lead analyst, Tim Grejtak, presents some key findings.

Not every country in the world can satisfy its demand for energy from domestically produced renewable sources. Some countries simply lack the land area and resource potential to power their energy-intensive economies.

"Places such as Singapore, Japan and the Netherlands are great examples of countries that cannot meet their energy demands solely through domestic renewable sources like wind and solar energy," says Grejtak, Lux Research analyst and the lead author of the report. "In fact, countries representing US\$9-trillion of global GDP cannot meet their energy demands solely through domestic renewable energy production and will require the import of renewable energy from more resource-rich countries," he explains.

To achieve their decarbonisation goals, these countries will need to find ways to import zero-carbon energy. Some of the ways identified for doing this include:

- Building new electricity infrastructure using high-voltage ac or dc transmission lines as a primary means of importing low-cost solar energy from distant regions.
- Power-to-gas technology using pipelines is limited and shipping liquefied hydrogen, methane or ammonia offers better

economics, but only over long distances.

- Imported energy costs can be competitive against other zero-carbon technologies, but no energy carrier can offer costs low enough to replace LNG or oil and offer a global renewable energy trade.

Not only is the demand for energy imports growing; it is also diversifying. New energy carriers such as liquefied natural gas (LNG) tankers are supplementing or, in some cases, substituting the traditional oil and coal vessels that have largely made up the mix of energy imports to date.

"Our analysis shows the expanded build-out of ac and dc powerlines will be the most cost-effective way of importing low-cost solar energy from distant regions, though only up to roughly 1 000 km. At farther distances, other renewable energy carriers such as synthetic fuels are less expensive. It's important to note that imported energy costs can be competitive against other zero-carbon technologies, but no current energy carrier can offer costs low enough to completely replace liquid natural gas (LNG) or oil," Grejtak adds.

Delivering energy via land-based powerlines or pipelines becomes expensive at long distances because of the inefficiencies of powerlines and the capital costs of pipelines. Delivery via ship, on the other hand, is

much more cost-effective at long distances, whether it be liquid organic hydrogen carriers (LOHCs) delivered by tanker or liquid hydrogen delivered using cryogenic carriers like those used for LNG.

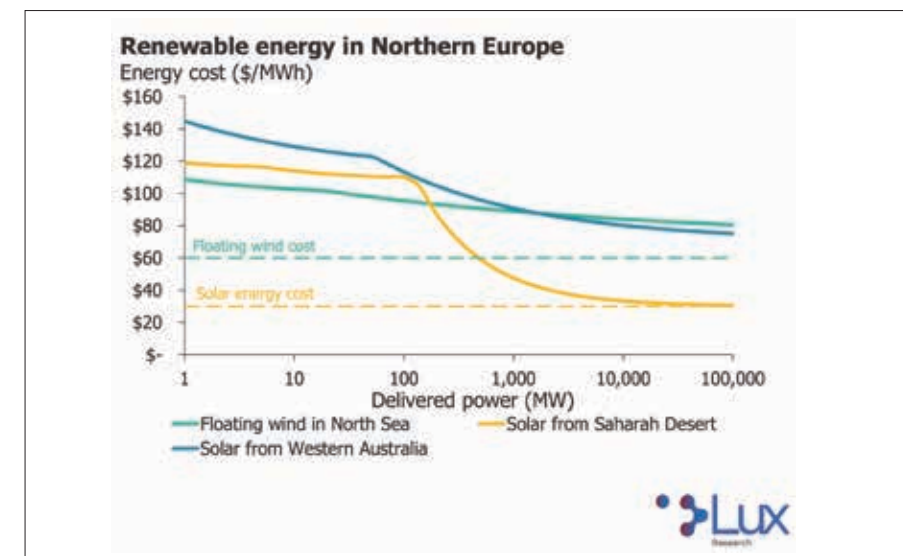
Crucially, Lux's analysis found that across all renewable energy carriers, low-cost solar energy can be delivered to resource-constrained regions at 50% to 80% lower costs than generating that solar energy locally under less favourable conditions. This value proposition will motivate the construction of billions of dollars of new infrastructure in countries committed to reducing their carbon intensity.

The report evaluated the lifetime costs of 15 different renewable energy carriers ranging from conventional carriers, including electricity, hydrogen, synthetic methane and ammonia; to more advanced carrier concepts such as LOHCs, vanadium and aluminium.

Specific energy carriers will dramatically reshape how particular regions access low-cost renewable energy. Combinations of liquid organic hydrogen carriers, high-voltage dc transmission and liquefied hydrogen are expected to enable energy-intensive economies to reach their CO₂ targets from 2030.

The report notes that:

- Successful projects will target multiple high-value applications and industry consortia will be key.
- Focusing on difficult-to-decarbonise sectors such as chemicals, heavy transportation and heat will make better use of energy carriers. These sectors intersect around industry, and partnerships among industry, logistics and renewable power generators will be essential.
- New infrastructure projects are not cheap and consortia are critical in or-



While solar resources in places like Northern Europe might be poor, they do have access to local high wind resources like the North Sea. Floating wind turbines may have higher electricity costs – estimated at \$60/MWh versus the modelled \$30/MWh value for solar – but, depending on power delivery, may offer lower costs than importing renewable energy from farther away.

der to reduce and share costs. These renewable energy carrier projects will cost of billions of dollars each and such costs cannot be borne by industry alone; governments will also have to play a role.

- A common global renewable energy trade is unlikely. Even with highly favourable conditions, high-volume energy carriers can only just match LNG prices today. If renewable energy displaces hydrocarbons, though, future LNG prices will be lower as demand drops.

Lux predicts the first tipping point for deploying renewable energy import infrastructure will be in 2030, when imported electricity via new HVDC power lines becomes cheaper than low-carbon natural gas turbines. The next tipping point will occur in 2040, when imported liquid hydrogen becomes cheaper

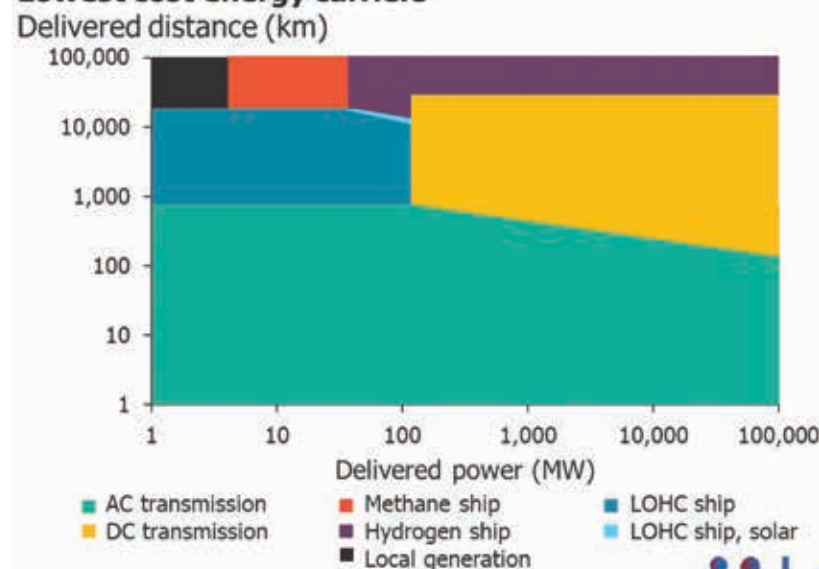
than low-carbon steam methane reformation. This gives companies today just 10 years to develop the partnerships and pilot projects necessary to demonstrate such a transformative energy paradigm.

Major companies, including Kawasaki Heavy Industries, Mitsui & Co, Equinor and Shell are already developing their own decarbonised energy trade routes in Europe, Japan, and Southeast Asia, meaning the fight for \$500-billion of energy imports in those regions is just beginning. □



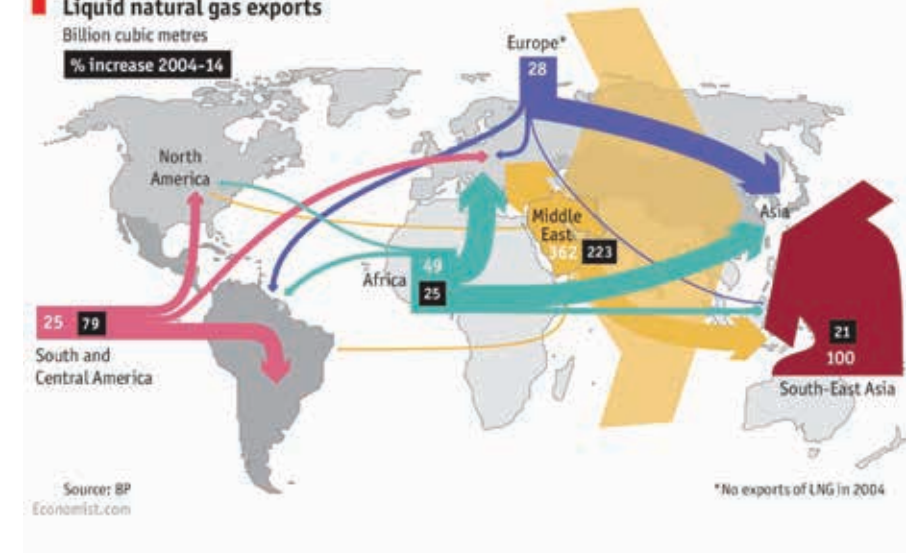
To view the executive summary of the report can be downloaded by scanning the attached QR code.

Lowest cost energy carriers



When comparing all energy carriers across all powers and distances, ac and dc power lines will provide the lowest-cost solution to connecting remote solar power systems to customers. Only at distances greater than 20 000 km when HVDC lines drop in efficiency, or greater than 1 000 km but less than 100 MW when HVAC lines drop in efficiency, does shipping appear competitive.

Liquid natural gas exports



Globally, 2 800 TWh of energy per year is transported from resource-rich regions, such as the Middle East, to energy-intensive regions, such as Southeast Asia.