

Fuel for Thought

Unlocking Bioenergy and Subsea Cabling to Power the Transition

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Beyond Boundaries:

How Biofuels and Subsea Cables Are Reshaping Global Energy

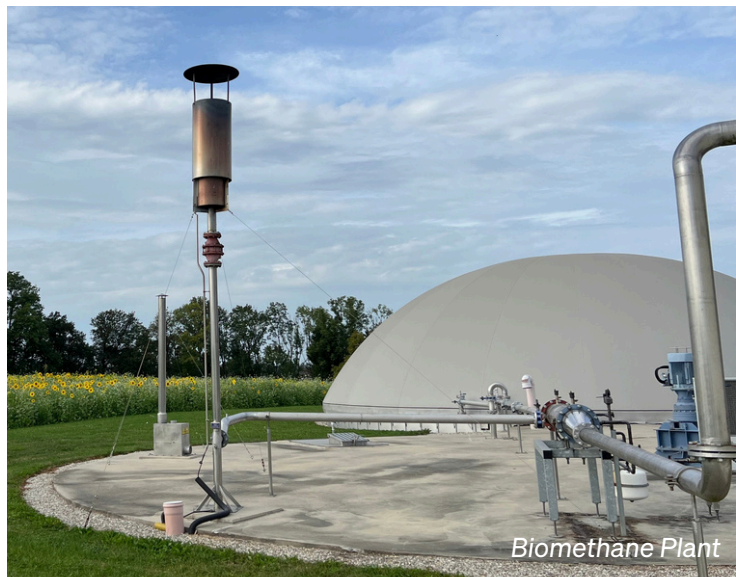
The energy transition is not a single technology story. It is a mosaic of solutions – some that harness waste to create fuel, others that span oceans to deliver power. Two of the most compelling frontiers are bioenergy, which turns organic materials into carbon-neutral alternatives to fossil fuels, and subsea power cables, which connect offshore renewable energy to mainland grids across borders.

Together, these pathways illustrate the ingenuity and determination required to build a sustainable energy future.

Bioenergy:

Turning Waste into Wealth

Bioenergy has emerged as a crucial component in the transition to cleaner energy systems. Derived from organic materials such as biomass and bio-wastes, bioenergy offers a carbon-neutral alternative to fossil fuels, making it an attractive solution for reducing greenhouse gas emissions.



Biomethane Plant

The carbon-neutral potential arises from a natural balance: CO₂ emissions during biomass combustion are offset by CO₂ absorption through photosynthesis during biomass growth. As urbanisation intensifies and waste production rises – projected to increase by 70 per cent by 2050 – efficient waste management solutions that integrate bioenergy technologies are becoming essential.

Feedstocks:

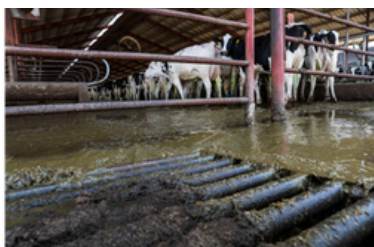
The Foundation of Bioenergy

Biofuel production relies on various feedstocks, each with distinct implications:

First Generation: Food-grade oils and crops like corn, sugarcane and soybeans. These are widely used for bioethanol and biodiesel but raise ethical concerns around food security and deforestation.

Second Generation: Non-food biomass sources such as waste vegetable oils, inedible animal fats and solid waste. These offer more sustainable options, mitigate food security concerns, reduce emissions and provide economic opportunities for farmers.

Third Generation: Innovative sources like algae and industrial by-products, which have high resource efficiency potential but require advanced conversion technologies for commercial viability.



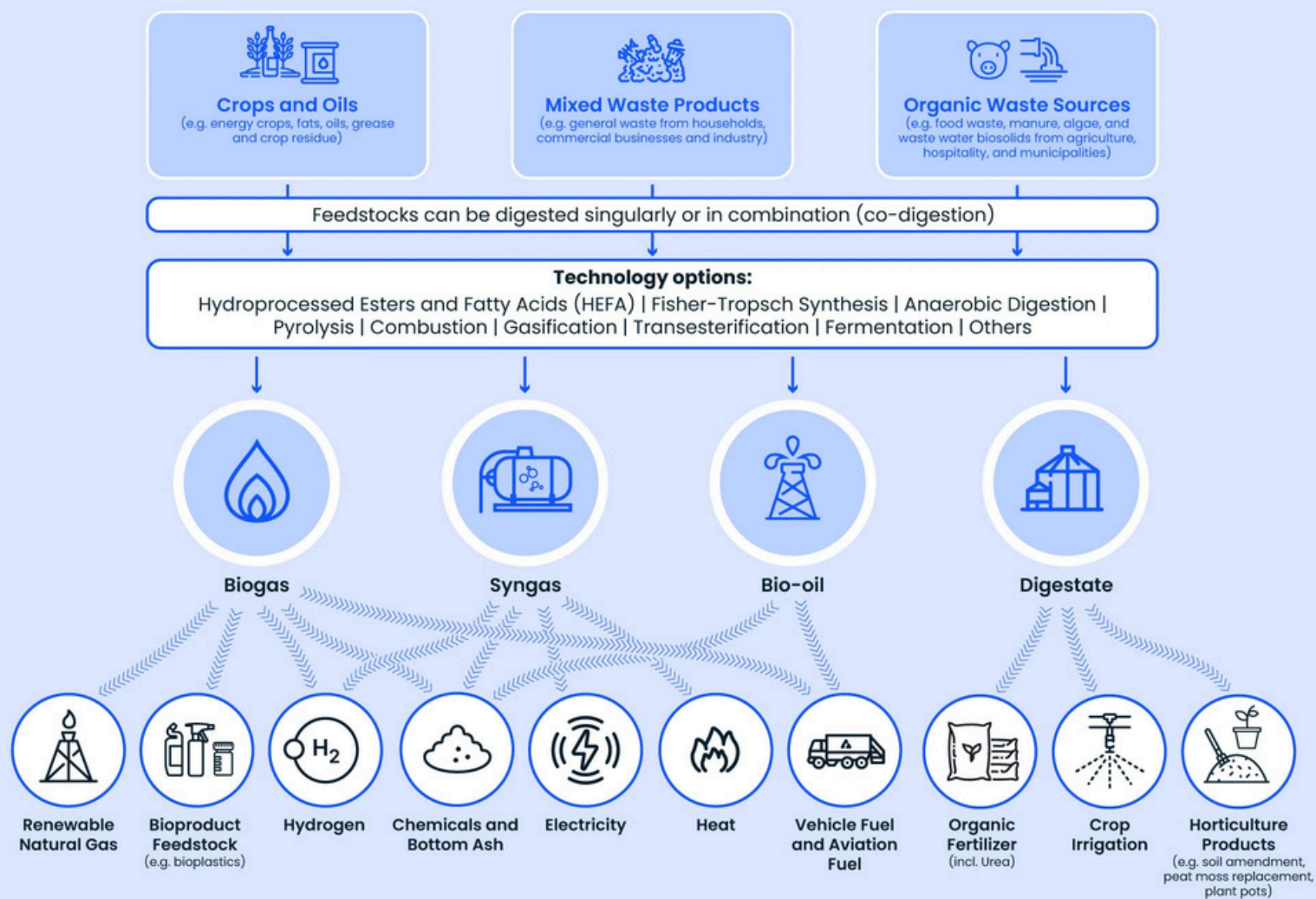
Feedstocks



Technological Pathways

Several technologies are converting biomass into renewable fuels:

- **Hydroprocessed Esters and Fatty Acids (HEFA):** Hydrogenates fats and oils to produce biodiesel and sustainable aviation fuel (SAF). Commercially viable but requires significant investment and faces intense competition for raw materials.
- **Gasification and Fischer-Tropsch Synthesis:** Converts biomass into syngas, then into liquid hydrocarbons. Enables high-quality fuel production from diverse feedstocks but requires advanced technology and capital.
- **Alcohol-to-Jet Fuel (AtJ):** Ferments biomass to produce alcohols converted into jet fuel. Offers a practical way to produce jet fuel without competing with food crops.
- **Power-to-Liquid (PtL):** Uses renewable electricity to produce hydrogen, combined with CO₂ to create synthetic fuels. Integrates renewable energy into fuel production but faces high electrolysis and carbon capture costs.
- **Pyrolysis and Hydrothermal Liquefaction:** Thermochemical processes that convert biomass into bio-oil or biocrude, requiring further refining to meet fuel specifications.
- **Anaerobic Digestion:** A biological process that breaks down organic matter to produce biogas and digestate. Effectively manages organic waste while producing renewable energy.
- **Direct Combustion:** Municipal Solid Wastes (MSW) is directly combusted in moving bed furnace and generate high pressure and high temperature steam to drive steam turbine to produce power to the grid. This is gaining momentum in developing countries due to urbanization.



Energy from Waste

Challenges and Opportunities

Despite its potential, biofuel production faces significant challenges:

Feedstock Availability: Ensuring a consistent supply of sustainable feedstocks is crucial. The competition between food crops and biofuel feedstocks must be managed to avoid compromising food security.

Sustainable Sourcing: There is a growing need for biomass sources that do not compete with food production. Second-generation feedstocks offer viable alternatives but require additional infrastructure for collection and processing.

With the bioenergy market projected to reach 233 gigawatts by 2030, innovative solutions and strategic investments will be critical in unlocking its full potential.

Subsea Power Cables:

Connecting Continents, Powering Progress

Just as biofuels transcend traditional fuel boundaries, subsea power cables are breaking geographic barriers, connecting offshore renewable energy to mainland grids across national borders. These underwater cables overcome not only physical obstacles but also regulatory challenges, enabling seamless cross-border energy flow.



Subsea Cables



Planning the Pathway

Effective planning of subsea cable routes begins with comprehensive desktop studies, often guided by the International Cable Protection Committee (ICPC) Recommendation No. 9. This initial phase focuses on identifying potential hazards and mitigating risks through thorough route selection:

- Avoiding obstacles such as boulders, shipwrecks and existing infrastructure.
- Navigating busy shipping lanes and environmentally sensitive areas.
- Adhering to stringent environmental regulations.

Stakeholder engagement and regulatory compliance are integral to smooth project progression. Consulting with maritime authorities, environmental agencies and other key stakeholders early on helps address concerns and streamlines the permitting process.



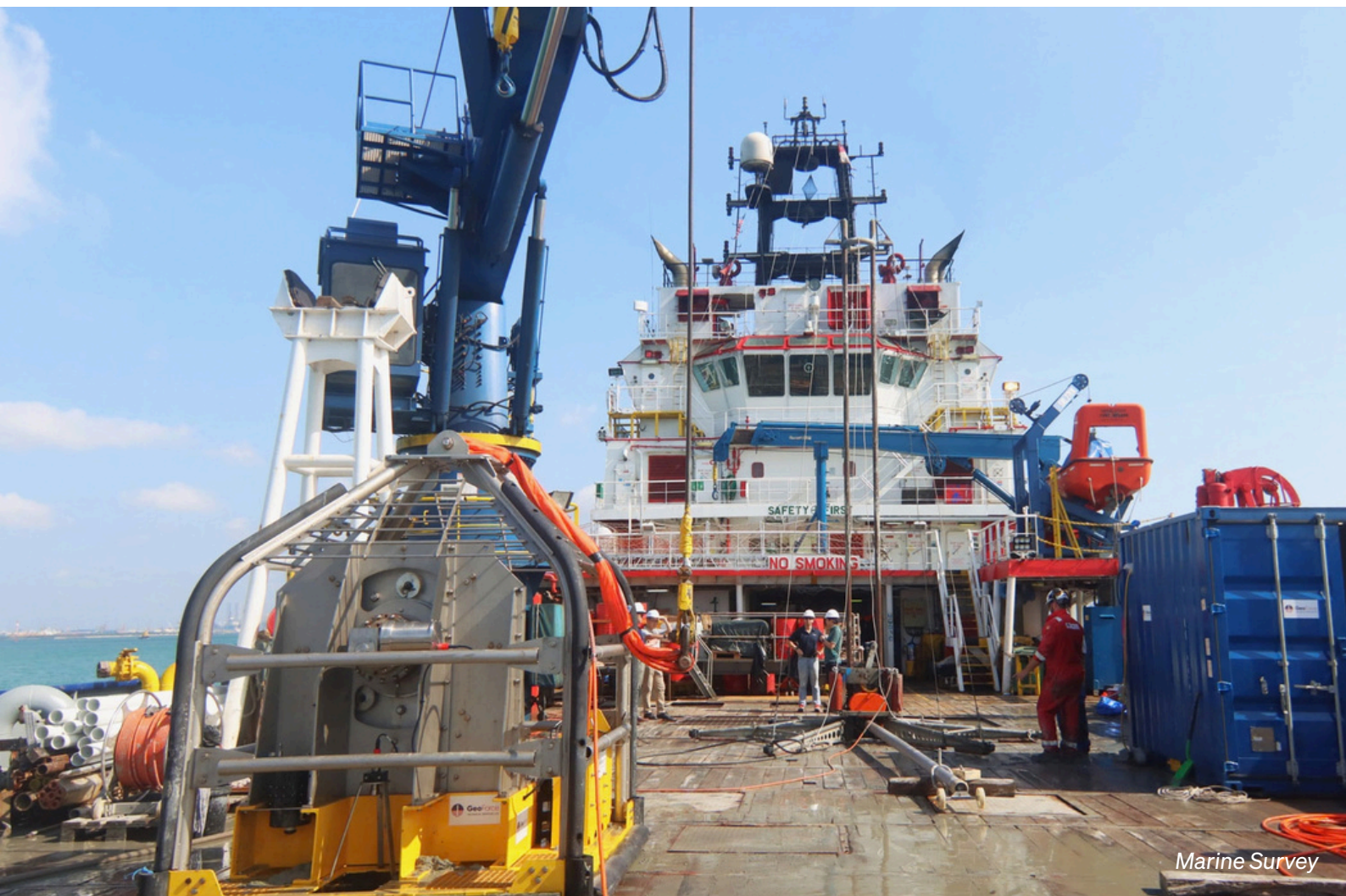
Marine Surveys: The Foundation of Success

Following the desktop study, marine surveys gather detailed site-specific data:

- **Geophysical surveys** employ multibeam echo sounders, side-scan sonars, sub bottom profiler and magnetometer to map seabed topography and identify underwater hazards.
- **Geotechnical surveys**, involving penetration tests and soil sampling, assess seabed sediment properties to determine cable burial feasibility.

Data from these surveys informs cable route optimisation, ensuring minimal environmental disruption and reducing the likelihood of construction delays.

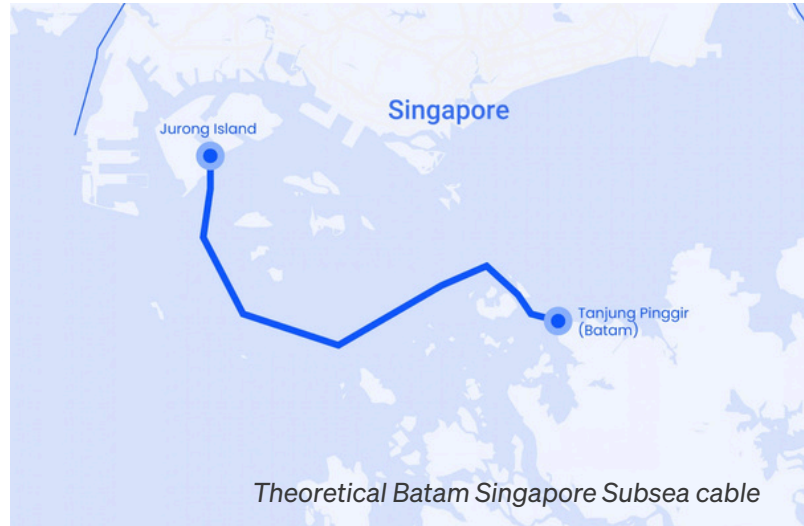
The Final Route Position List (RPL) generated from survey data provides precise geographic coordinates, ensuring accurate alignment and long-term viability.



Marine Survey

A Case in Point

The proposed Tanjung Pinggir (Batam) – Jurong Island (Singapore) theoretical subsea power cable study is part of ongoing efforts to facilitate green energy power imports. This project exemplifies the planning and collaboration required to realise cross-border energy connections, from desktop studies through marine surveys to final route selection.



Conclusion

Bioenergy and subsea power cables represent two ends of the energy transition spectrum – one transforming waste into fuel, the other spanning oceans to deliver clean power. Both are essential components of the solution.

Bioenergy offers a promising pathway towards decarbonisation by leveraging waste materials and sustainable feedstocks. Subsea cables unlock renewable energy potential by connecting offshore generation to demand centres across borders. Both require meticulous planning, technological innovation and strategic investment.

At Surbana Jurong and SMEC, our Global Energy business is developing solutions across the entire energy value chain – from fuels and renewables to transmission and storage. As the adage goes, there is no transition without transmission. And there is no energy transition without innovation across every link in the chain.

The boundaries that once constrained energy – geographic, technological, regulatory – are being redrawn. The energy future is not only cleaner but more connected, more efficient and more sustainable. Together, we are making that future a reality.



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