Jacobs Challenging today. Reinventing tomorrow.

Distributed Renewable Energy & Microgrid Solutions

Pacific Islands | 2022

Jacobs at a Glance

58,000+
Employees

400+
Locations

40+
Countries

$14B
2021 Revenue

$2.5B
2019 Client Savings

23.8 M
2019 Metric Tonnes co_2 Emissions Avoided for Clients

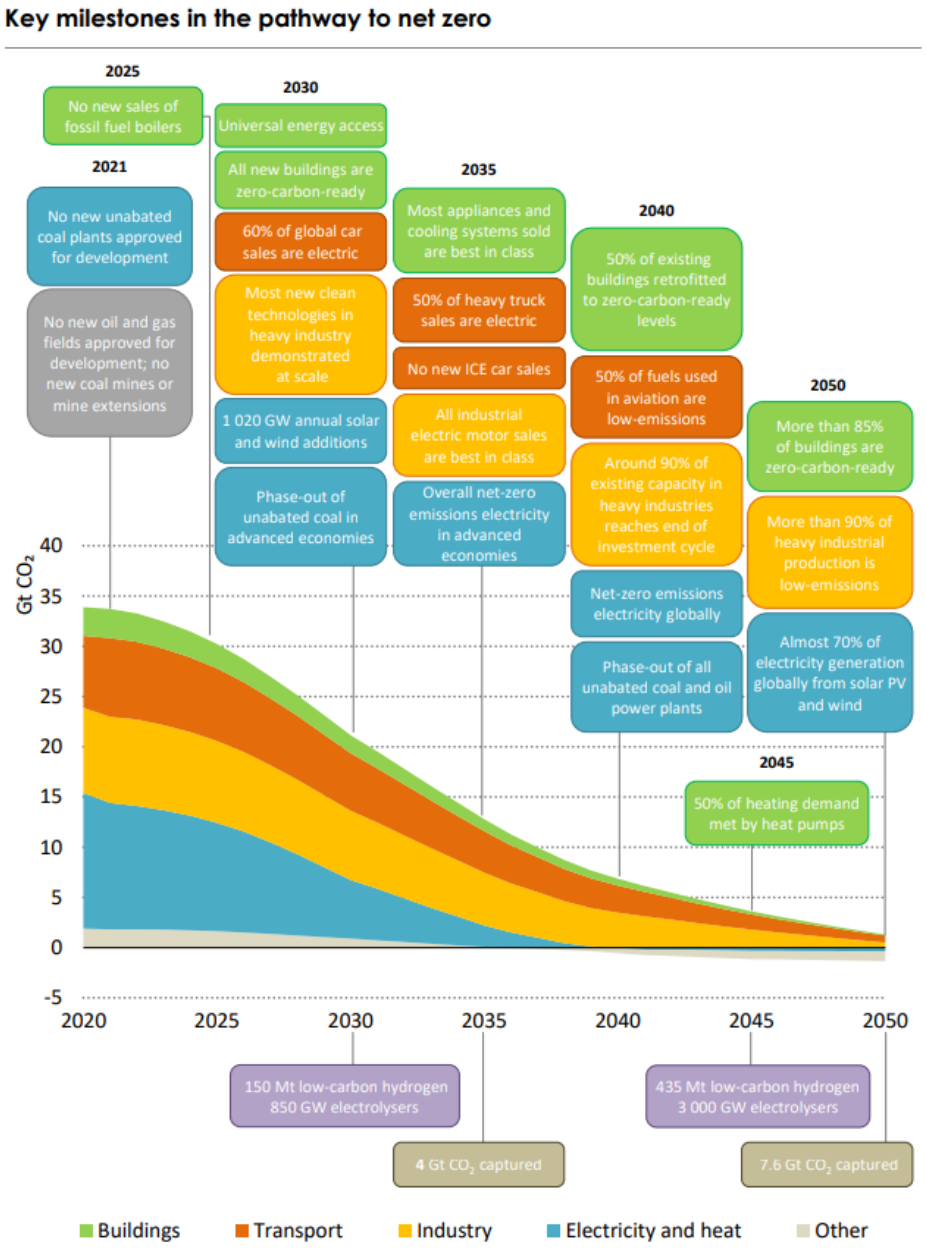
$23.8B
In Backlog

Ranked No.1 in our industry on **Fortune's 2020** World's Most Admired companies list

Engineering News-Record ranked **Jacobs No. 1** in its list of **Top 500** Design Firms in the world in **2020**

IEA Pathway to Reach Net Zero

- **Total annual energy investment**
  - Surges to USD 5 trillion by 2030
- **Annual investment in transmission and distribution grids**
  - from USD 260 billion today to USD 820 billion in 2030.
- **Public EV charging points**
  - Rises from 1 million today to 40 million in 2030,
  - Annual investment of almost USD 90 billion in 2030.
- **Annual battery production for EVs**
  - leaps from 160 gigawatt-hours (GWh) today to 6 600 GWh in 2030 - the equivalent of adding almost 20 Gigafactories
  - 2 each year for the next ten years.
- **Hydrogen and CCUS after 2030**
  - Annual investment in CO2 pipelines and hydrogen-enabling infrastr ucture increases **from USD 1 billion today to** around **USD 40 billion in 2030**.
- **Resource Transition**
  - Total market size of critical minerals like copper, cobalt, manganese an d various rare earth metals grows almost sevenfold between 2020 and 2030 in the net zero pathway



Energy Transition Sector Activity

Federal & Environmental

- Decarbonization of federal assets & supply chain
- Defense sustainability
- Decarbonizing infrastructure
- Developing policy & regs, incentivizing NetZero

Transport

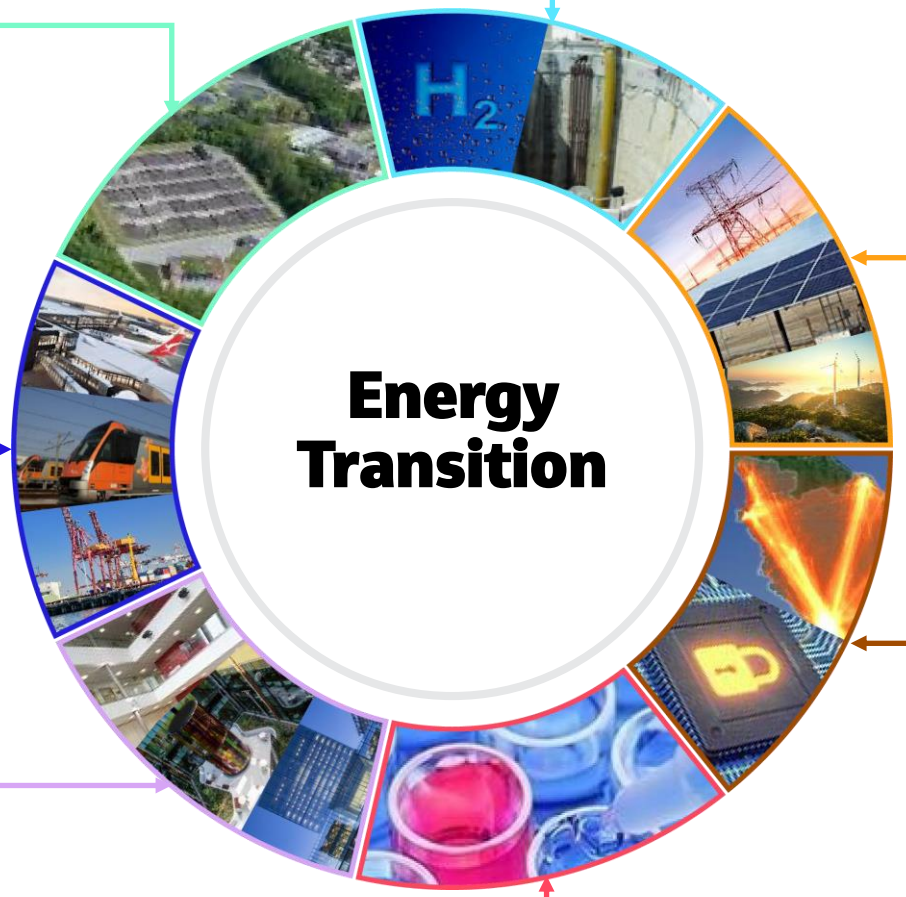
- HFC for rail and heavy transport
- Rapid EV adoption and network roll-out
- Hydrogen aviation infrastructure
- Ammonia, methanol as a bunker fuel

Cities & Built Environment + Advanced Facilities

- Decarbonization of supply chains
- Integration of renewables, HFCs, energy storage
- Ground/air source heat pumps for cooling/heating

Industrial manufacturing

- Electrification of processes
- H2 for industrial process heat
- Green H2 feedstock
- Low carbon cement, steel, fertilizer, refining



Water

- WWTP being reinvented as an energy hub
- Hydrogen and oxygen generation for bioreactor utilization
- Ammonia recovery

Power & Renewable Energy (& Nuclear)

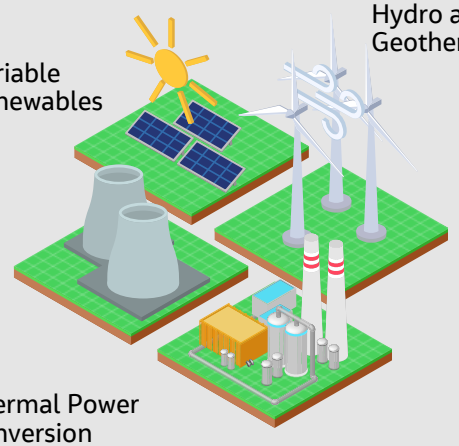
- Energy storage
- Transmission and distribution
- Renewable generation
- Interconnections
- Thermal power conversion
- Microgrids
- Hydrogen production, transport and downstream end use
- Hydrogen: liquified & carriers including LOHC
- Carbon capture storage and utilization (CCSU)
- Ammonia for combustion
- EV Fast chargers
- Nuclear H2 baseload
- Remote energy production
- Waste to X

Security, Digital, Advisory

- Cyber-security of multi-point distributed energy assets
- Real time monitoring and optimization
- AI planning and design automation
- Smart grid-smart assets – demand management
- Energy efficiency and benchmarking

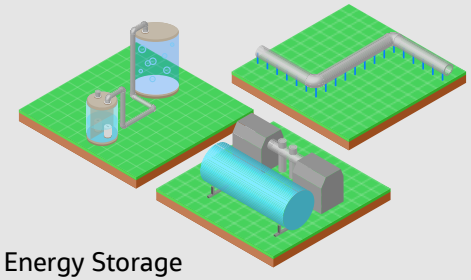
Resilience and Smart Generation, Grid & Asset Integration

Generation

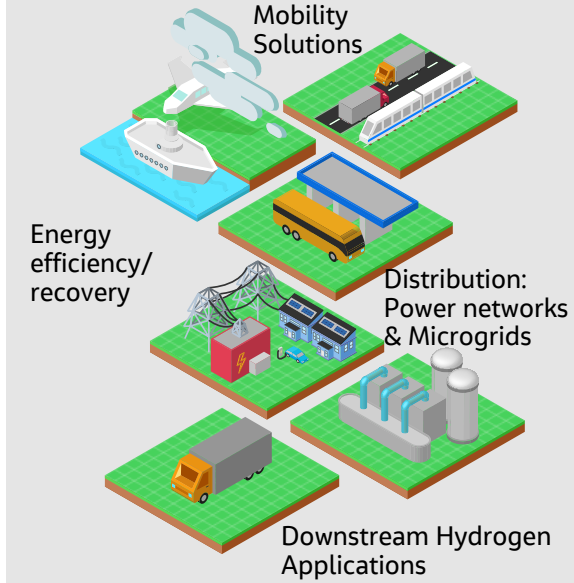


Transmission, Storage & Distribution

Transmission & Interconnections



Integrated Energy Solutions: Urban, Commercial & Industrial



Distributed Low Carbon

- Integrated decentralized/ dispersed Renewables & storage
- Decarbonizing thermal power
- Energy storage and dispatchability
- Transition to hydrogen and ammonia power generation
- Off-grid generation and storage

Interconnections & Smart Grids

- Dynamic planning & network model simulation
- Grid modernization roadmap development
- Advanced monitoring & sensing, remote inspection
- Balancing variable supply and increasingly smart assets
- Aging infrastructure assessment & replacement
- Grid security assessment & planning
- Automation and control
- Data analytics

Demand Management

- Microgrid development
- Mobility: Modelling & managing EV capacity demands
- Energy efficiency & comparison against Best Available Technologies (BAT)
- Benchmarking & Asset Improvement Programs
- Interoperability of Smart Assets with smart grids/generation/storage
- Utility systems studies
- Digital monitoring and reporting
- Remote operations

Decarbonization → Sustainability → Electrification → Flexibility → Efficiency → Urbanization → Resilience

Island Energy Options

Generation

Variable Renewables

Hydro and geothermal

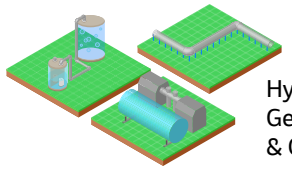
Thermal Power Replacement & Conversion

Waste and Biomass to Energy

Distributed Low Carbon Power

Transmission, Storage & Distribution

Transmission & Interconnections



Energy Storage

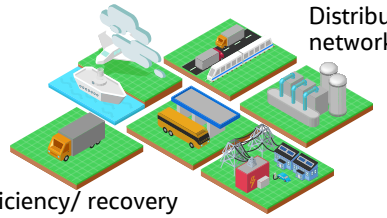
Hydrogen Generation, Storage & Conversion

Interconnections & Smart Grids

Integrated Energy Solutions: Urban, Commercial & Industrial

Mobility Solutions

Distribution: Power networks & Microgrids



Energy efficiency/ recovery

Downstream Hydrogen Applications

Demand Management

Challenges

- Is the energy available when you need it?
- Can it endure major weather events?
- How to incentivize low carbon energy developments?

- How to provide firm carbon free energy over time?
- How to reduce the costs of energy imports?

- What are the main sources of energy demand?
- How to lower consumer's energy bills?

Opportunities

- Integration of smart distributed generation to reduce fuel imports.
- Development of future ready hybrid systems, that can transition over time

- New energy storage technologies
- Batteries, flow batteries, hydropower, hydrogen

- Managing demand
- Energy efficiency and optimization
- Decarbonizing the supply chain
- Vehicle to grid and decentralized storage

Decarbonization > **Sustainability** > **Electrification** > **Flexibility** > **Efficiency** > **Urbanization** > **Resilience**

Distributed Renewable Energy & Micro-Grid Solutions

UTILITY & MICROGRID

Moving from the 'dumb' grid to a responsive smart, **and secure**, asset operating in a dynamic environment

ENERGY STORAGE

BESS, Hydrogen, Vehicle to Grid (V2G), Hydro

Capital costs for battery energy storage systems (BESS) have dropped significantly allowing DRE projects to be more dispatchable, able to follow load patterns, and shift building peak loads

BUILDINGS & INDUSTRY

Energy efficient design
Demand Response
Best Available Technologies (BATs)

MICROGRID CONTROLLER

TRANSPORT

Light mobility and the shift to EVs.
Decarbonizing shipping via Ammonia
Electric and hydrogen aviation biofuels

HYBRID GENERATION & CHP

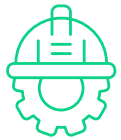
Utilizing the most efficient technologies to combine heat and power utilization.

Development of hybrid Gas turbine and solar systems, including BESS

RENEWABLES

Solar, wind, green hydrogen, biomass, biogas, geothermal, and small hydro

Jacobs Capabilities & Considerations Across the Energy Project Development Lifecycle



ENGINEERING SERVICES

Pre-Development	Feasibility	Preliminary Design	Detailed design / Construction Documents	Program Delivery	Commissioning & Start-Up	Optimisation
▪ Resource Analysis ▪ Environmental planning and permitting ▪ Site constraint identification ▪ Funding assistance ▪ Grants, Incentives	▪ Risk identification and mitigation ▪ Solar and storage technology evaluation ▪ Shading analysis and ground coverage ratio definition ▪ Conceptual layout ▪ Utility routing and interconnection ▪ Structural feasibility ▪ Class 3/4 cost estimate ▪ Plant performance and economis	▪ Plant general arrangement ▪ Project schedule ▪ Electrical one-lines ▪ Specifications ▪ Geotechnical review ▪ Glare analysis ▪ Procurement package support ▪ Bid review and selection of EPC contractor ▪ Class 2 cost estimate	▪ 60%/90% design documentation and review ▪ Class 1 cost estimate ▪ Review drawings and document submittals including site studies ▪ Commissioning plan review ▪ Performance testing procedure review	▪ Construction oversight and monitoring ▪ Review project materials and project construction against specifications	▪ Operation commissioning oversight ▪ Review commissioning summary report and final acceptance and handover	

STRATEGIC ADVISORY & CONSULTING SERVICES

▪ Strategy and roadmap development ▪ Concept development ▪ Site selection ▪ Technology evaluation and benchmarking ▪ Licensor engagement & selection ▪ Tender document preparation ▪ Financing and financial model support, grant assistance ▪ Upgrade evaluation ▪ Environmental, social& planning permitting strategies ▪ Design review ▪ Commissioning and performance testing ▪ Due diligence – M&A support across technical, commercial and environmental aspects		▪ Specification and scoping ▪ Dynamic planning & network model simulation ▪ Bid evaluation and negotiation ▪ Upgrade evaluation ▪ Engineering studies ▪ Balance of plant engineering ▪ Environmental design ▪ Design review & independent validation/ assurance ▪ Risk management & Health and safety plans	▪ 60%/90% designs ▪ Instrumentation and controls (SCADA) ▪ Equipment plans / procurement ▪ Electrical design & utility coordination ▪ Detailed schedule ▪ Finalized permits and licenses ▪ Site preparation and mobilization ▪ 100% construction documentation ▪ Commissioning plan ▪ Digital Twin	▪ Auditing/Monitoring for owners & lenders	▪ Confirm procedures for O&M and emergency ▪ Review commissioning summary report and final acceptance and handover ▪ Dispute resolution ▪ Works inspection	▪ Plant optimization and thermodynamic modelling ▪ Energy efficiency assessment and upgrades ▪ Digital monitoring and reporting systems ▪ Cyber security ▪ Financial model support ▪ Upgrade evaluation ▪ Environmental permitting ▪ Auditing - Energy ▪ Due diligence and independent engineering ▪ Expansion and performance improvement studies

DECARBONIZATION | SUSTAINABILITY | ELECTRIFICATION | FLEXIBILITY | EFFICIENCY | URBANIZATION | RESILIENCE

Lord Howe Island Hybrid Renewables, Australia, 2015 - 2020

Client: Australian Renewable Energy Agency

Role: Feasibility, Owners Engineer, Project Management

Lord Howe Island, a volcanic remnant located in the South Pacific Ocean approximately 600 km east of Port Macquarie and 780 km north east of Sydney. Jacobs was engaged by Lord Howe Island Authority to undertake a Feasibility Study, then as the owners engineer to design and manage the construction of a microgrid to replace existing aging generation.

The island is listed as a UNESCO World Heritage Site of global natural significance and is listed on the Australian Natural Heritage List and the NSW State Heritage Register. The island is home to approximately 350 residents and only 400 visitors permitted at any one time. Tourism and export of Kentia Palms are the key industries on the Island.

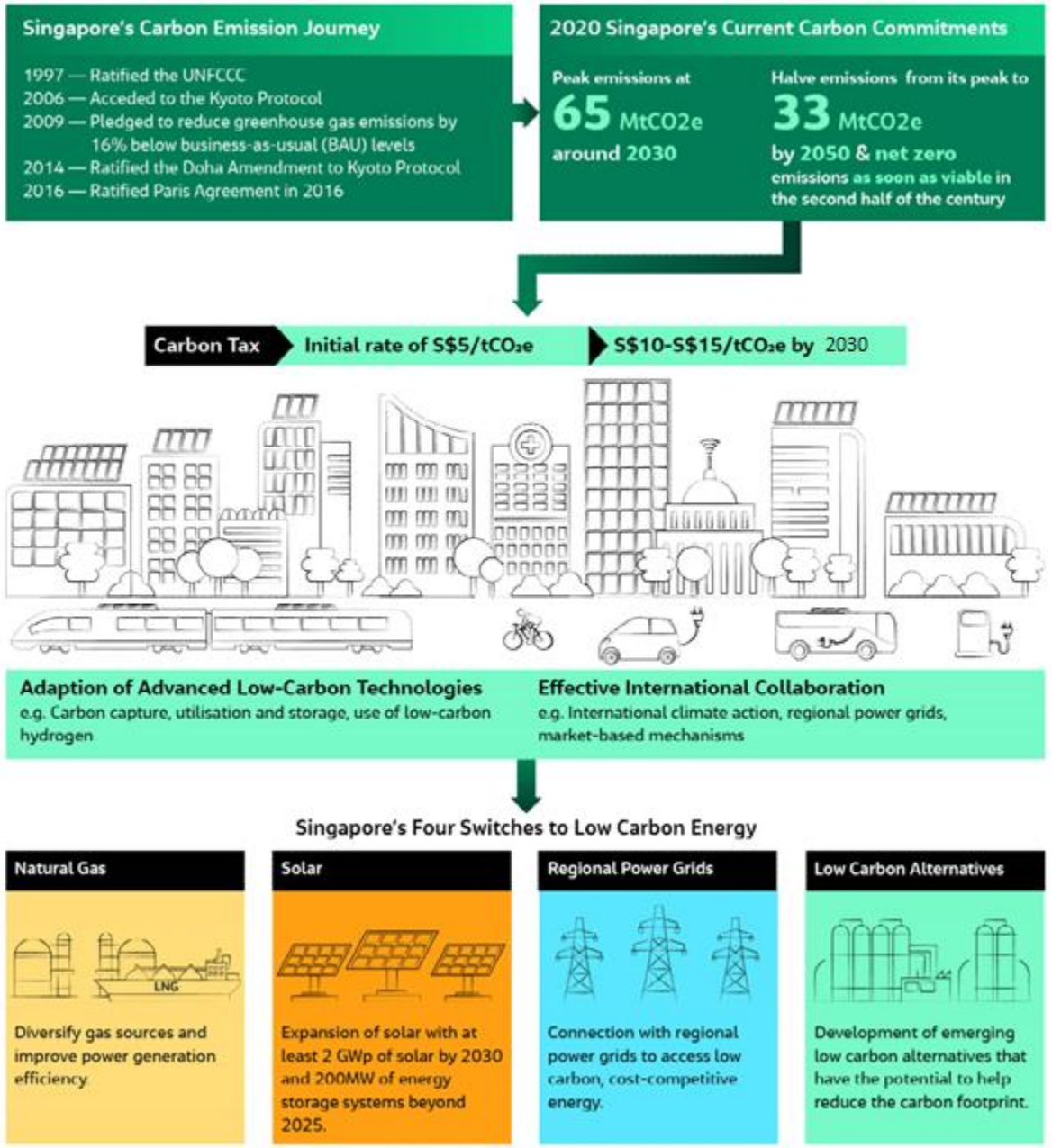
•The hybrid renewable energy project including more than 1.3 MWp solar PV array, an integrated control system and over 3.7 MWh of battery storage – is set to provide at least two thirds of the electricity needs of the Lord Howe Island community. The system will significantly reduce the Island's reliance on expensive, shipped-in diesel, which means reduced emissions, better energy security, and buffering against diesel price shocks.
•Funding for the $11.1 million project was secured through a $4.5 million grant from the Australian Renewable Energy Agency (ARENA) and a $5.9 million loan from the New South Wales Government (to be paid back via diesel fuel savings), with the balance of funds contributed by the Lord Howe Island Board. A condition of the funding was that the system provides 67% of the island's annual energy.

- Jacobs correlated 3 months of site-measured data with long-term satellite (SolarGIS) data and using PVSyst, modelled the installation, investigated several scenarios and technologies and calculated the expected long-term energy production.
- Owner's engineering capacity, provided project management and community consultation services during the design and construction phases.
- Detailed design review for compliance with the contract specification and appropriate standards,
- Provided supervision services throughout construction and commissioning, including as the island transitioned to the new battery system.

Case Study: Singapore's Targets & Approach

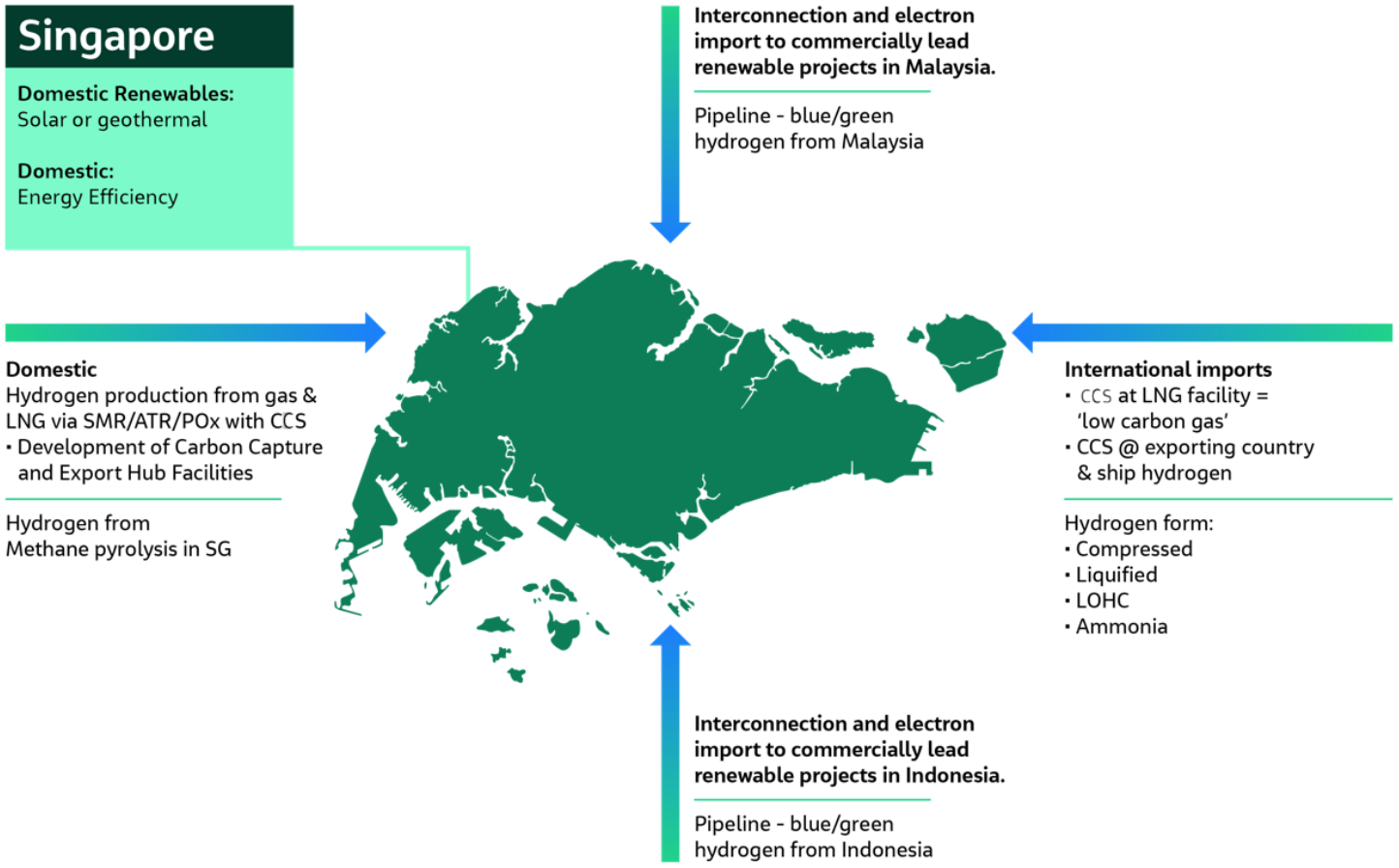
- Vast majority of energy requirements met with natural gas:
  - 95% of Singapore's electricity
- 89% Energy for power and industry

- Singapore's focus on its 'Four Switches'
  - Focus on improving efficiency of power generation companies.
  - Expansion of solar on rooftops and primarily as floating solar both within Singapore waters and within the vicinity (i.e. Bintan and Batam).
  - Connection with regional power grids to access low carbon, cost-competitive energy.
  - **Development of emerging low carbon alternatives** (e.g. hydrogen, carbon capture, utilization and storage technologies) that have the potential to help reduce its carbon footprint

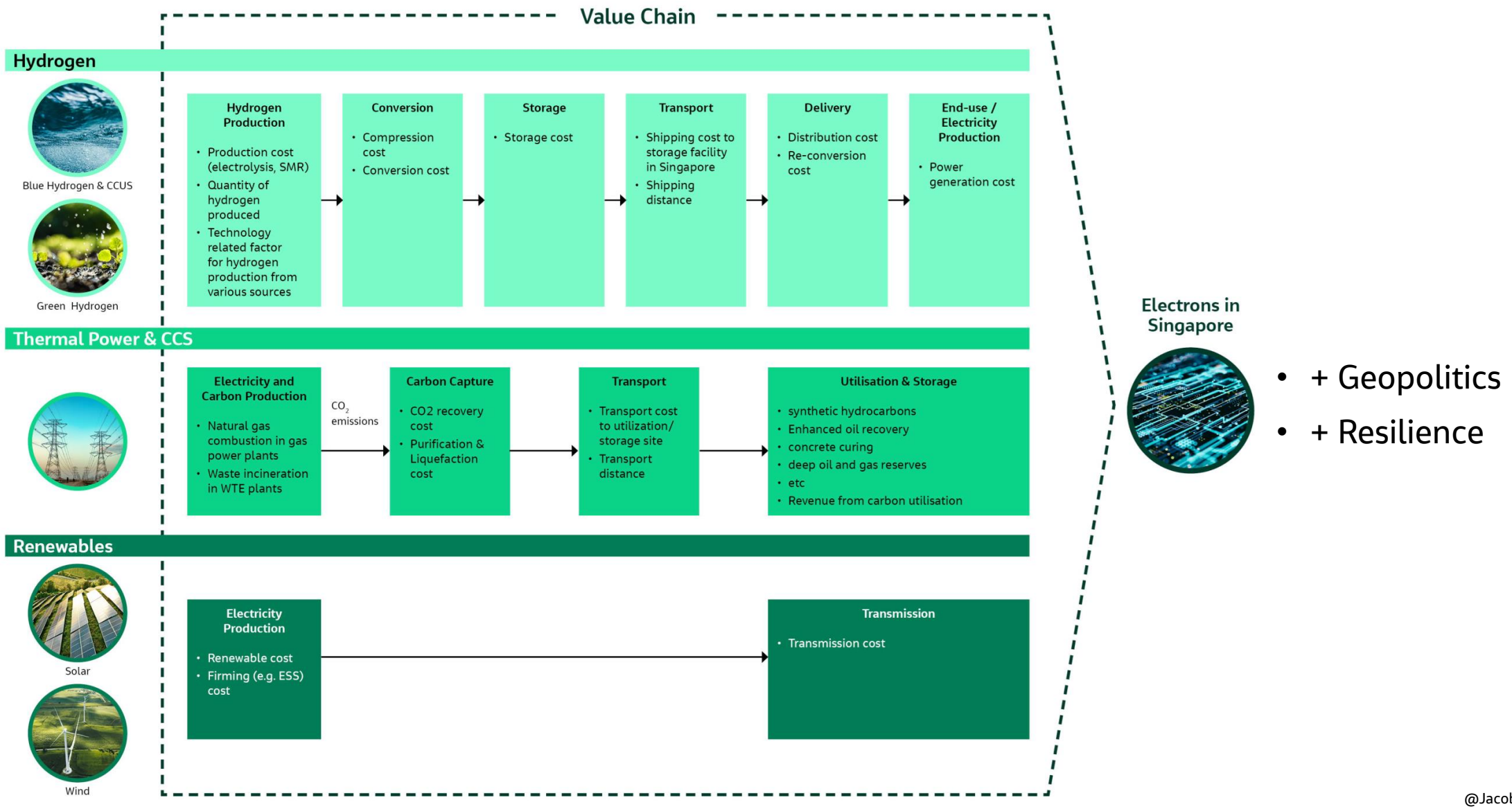


Case Study: Singapore's Low Carbon Energy Supply Options

- Energy demand is expected to continue to increase, given the rising demand for energy from data centers, 5G networks and electric vehicles
  - Reinvention of Jurong Island
- Over 80% of industrial land space is already allocated
  - limiting opportunities for expansion of commercial and/or industrial activities
- Renewable energy potential?



Case Study: Low Carbon Options for Singapore



- + Geopolitics
- + Resilience

Relevant Projects

Floating Solar - 6.7 MWp, 1.5 MWp, 1.0 MWp, Singapore

Floating PV Solar System at Upper Peirce Reservoir
6.7 MWp 1,500Vdc system - 50m setback, 72 cells 365Wp

Singapore Floating Solar PV Under Construction on Reservoir.

Client: Public Utilities Board
Role: Owner's Engineer

Project Description

Jacobs interfaced with the client to support the development of a floating solar PV facility to be located on a drinking water reservoir. Our team developed the initial designs, worked with electrical engineering team to identify safety concerns, identified electrical connection points, and developed four electrical configuration options. We served as the primary solar technical interface for the client on conference calls and meetings in Singapore.

We completed a first phase basis of design, looking at details including dam loading for cranes, developing specifications for a floating construction platform, determining safe distances for water activities, and developing different inverter options. We completed a performance estimate of the array, given the special thermal properties of a floating solar array. We consulted with our environmental and computational fluid dynamics team members to understand the impact to the ecosystem.

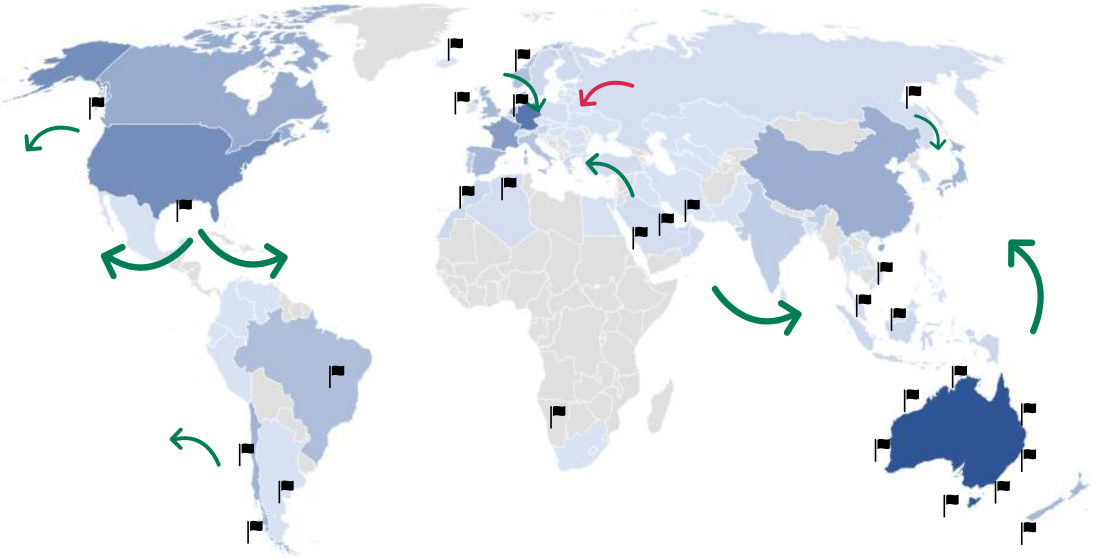
Jacobs engineers from the United States and Asia developed construction drawings and bid documents to assist the client in hiring a contractor to install the floating PV systems.
A contractor has been selected and the first system is under construction.

Challenges and Solutions

The environmental effects of installing a floating solar PV system on a potable water reservoir supply were considered in a detailed analysis. Our design ensures that the wildlife living in and around the reservoir are protected.

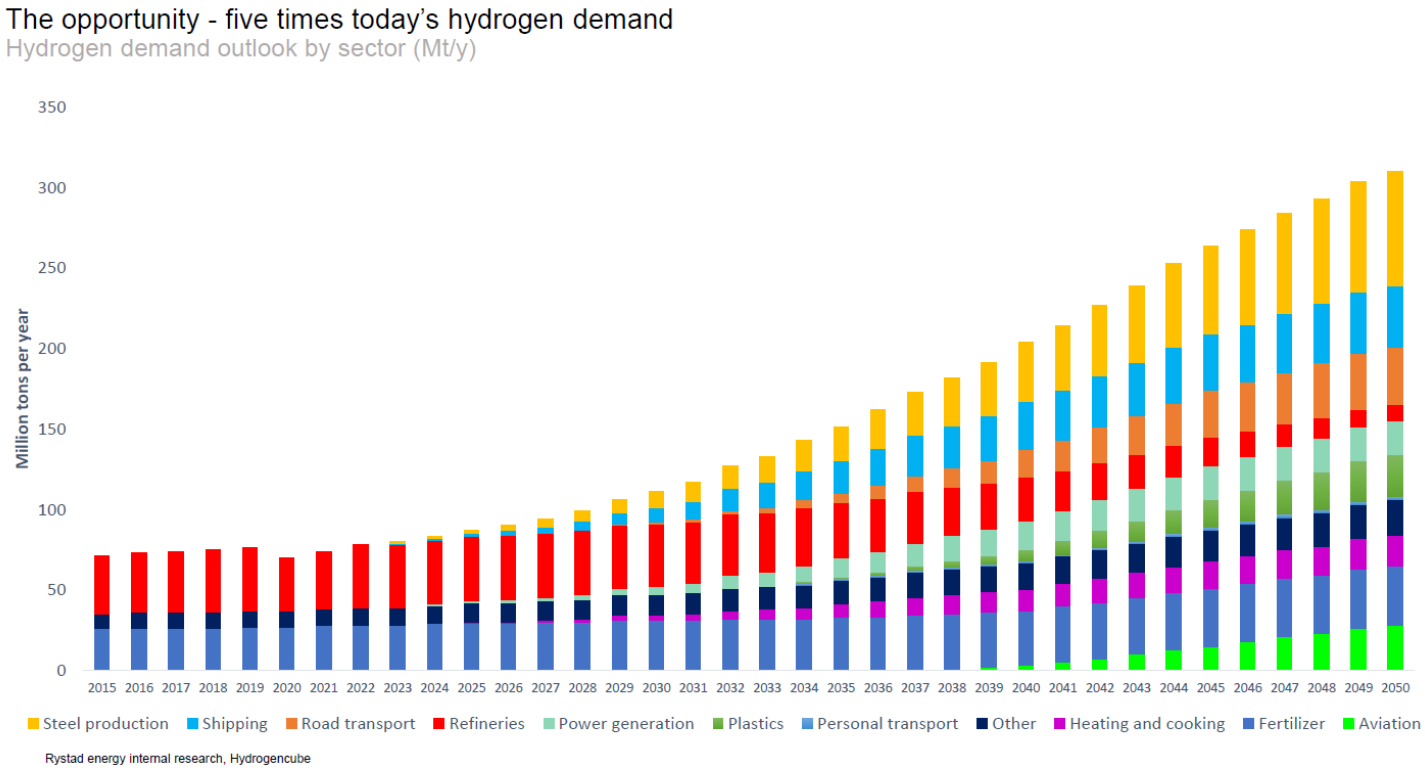
Safety for O&M staff was a major concern. Space between solar module rows are installed with strong floatation was included. Electrical safety was also considered regarding the 1000 volt DC cables entering the water. An additional challenge was ensuring the floating system is well anchored to the bottom of the resorvoir.

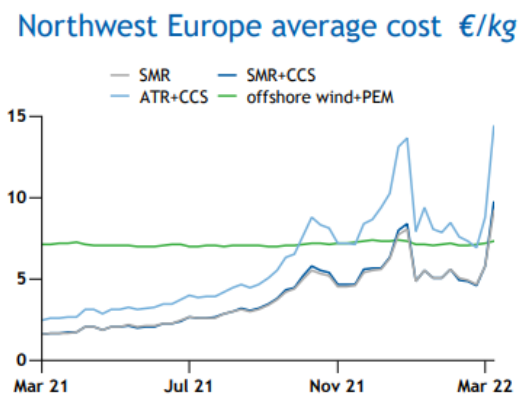
Energy Transition Index: An Emerging Hydrogen Supply Chain

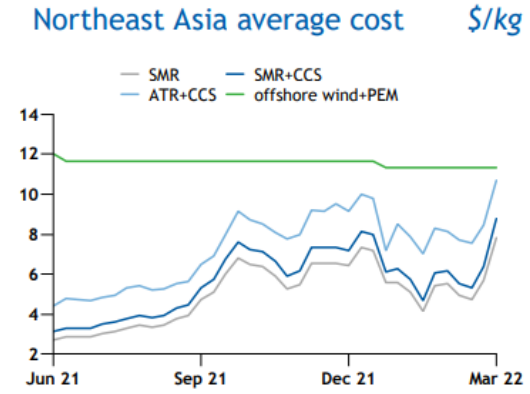


Jacobs ET Index based on:

- Net Zero Targets (Drivers of Transition)
  - Legally binding & Supportive legislative regimes
  - Policy
  - Hydrogen strategies adopted or under development
  - Carbon price/ETS
- Resource Potential
  - Fastest renewable growth since 2010
  - Greatest renewable resource
- Renewable investment planned/foreseeable







Source: Argus Media

Jacobs Energy Experience

Generation

Renewables

Thermal Power Conversion

Nuclear: SMR

Waste to Energy

Hydrogen Production

Generation & Storage

Geothermal
40 years experience.
More than 100 geothermal resources, over 3,000 MW of generation, in over 20 countries, comprising more than one third of the world's geothermal power generation capacity

Thermal Power
Jacobs was responsible for development of concept design, Front End Engineering Design (FEED) and Owner's Engineer (OE) to CLP Power HK, for a 550MW-650MW CCGT at CLP's Black Point Power Station (BPPS).

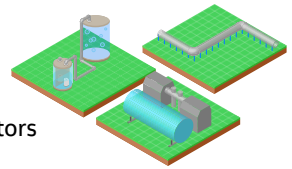
Wind and Solar
The 420MW Macarthur Wind Farm is Australia's largest wind farm project in South-Western Victoria. Jacobs supported from initial stages through to Owner's Engineer (OE) role during construction and commissioning.

Nuclear Fusion
Design and delivery of the First Plasma Radiological Environmental Monitoring System (REMS), a key safety system for ITER, the world's largest fusion power project aimed at commercial production of fusion-based electricity.

Transmission, Storage & Distribution

Transmission & Interconnections

Energy Storage
Hydrogen & Vectors
Supply Chain

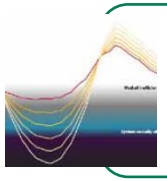


Interconnections & Smart Grids

Interconnections
Jacobs is currently providing an integrated delivery partner approach to program and contract management, planning, and stakeholder engagement for the $11B, 700km SuedLink project in Germany.

Energy storage
Development of an overarching control system for integration of a 21MW/34MWh BESS with the 100MW Snowtown Wind Farm (WF).

Transmission
Program management, early contractor involvement, design and construction to deliver National Grid's performance-based substation regulatory program. National Grid estimates the contract value at $1.3 billion (£1 billion).

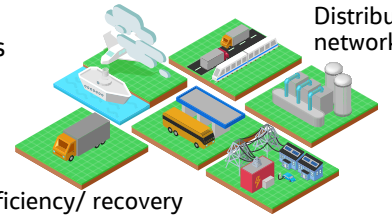


Microgrids
Jacobs developed an energy strategy for critical facilities in Puerto Rico. creating a 1 MWAC scalable microgrid, consisting of solar pv generation and long-term storage options including batteries and hydrogen storage.

Integrated Energy Solutions: Urban, Commercial & Industrial

Mobility Solutions

Distribution: Power networks & Microgrids



Energy efficiency/ recovery

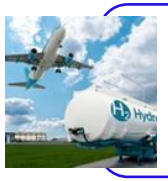
Downstream Hydrogen Applications

Demand Management

FLEET MAX Energy Modeling
Jacobs developed software solution to support the conversion of vehicle fleets from fossil fuels to zeroemission alternatives; considers fleet operation, including transport service, electric power, cost.

Sustainable Data Centers
Global delivery partners for major technology companies, developing low carbon energy supply chains to power data centers with 24/7 low carbon energy.

Efficient Manufacturing
Jacobs supported a global sporting goods manufacturing company develop concepts and assess technologies for renewable energy and storage integration into new manufacturing facilities across Asia.



Hydrogen Aviation
Airport Infrastructure for Hydrogen Aircraft, FlyZero : UK Government's Department for Business, Energy & Industrial Strategy (BEIS) project to help UK aerospace develop a zero carbon emission aircraft by 2030.

Decarbonization › Sustainability › Electrification › Flexibility › Efficiency › Urbanization › Resilience

Thank You

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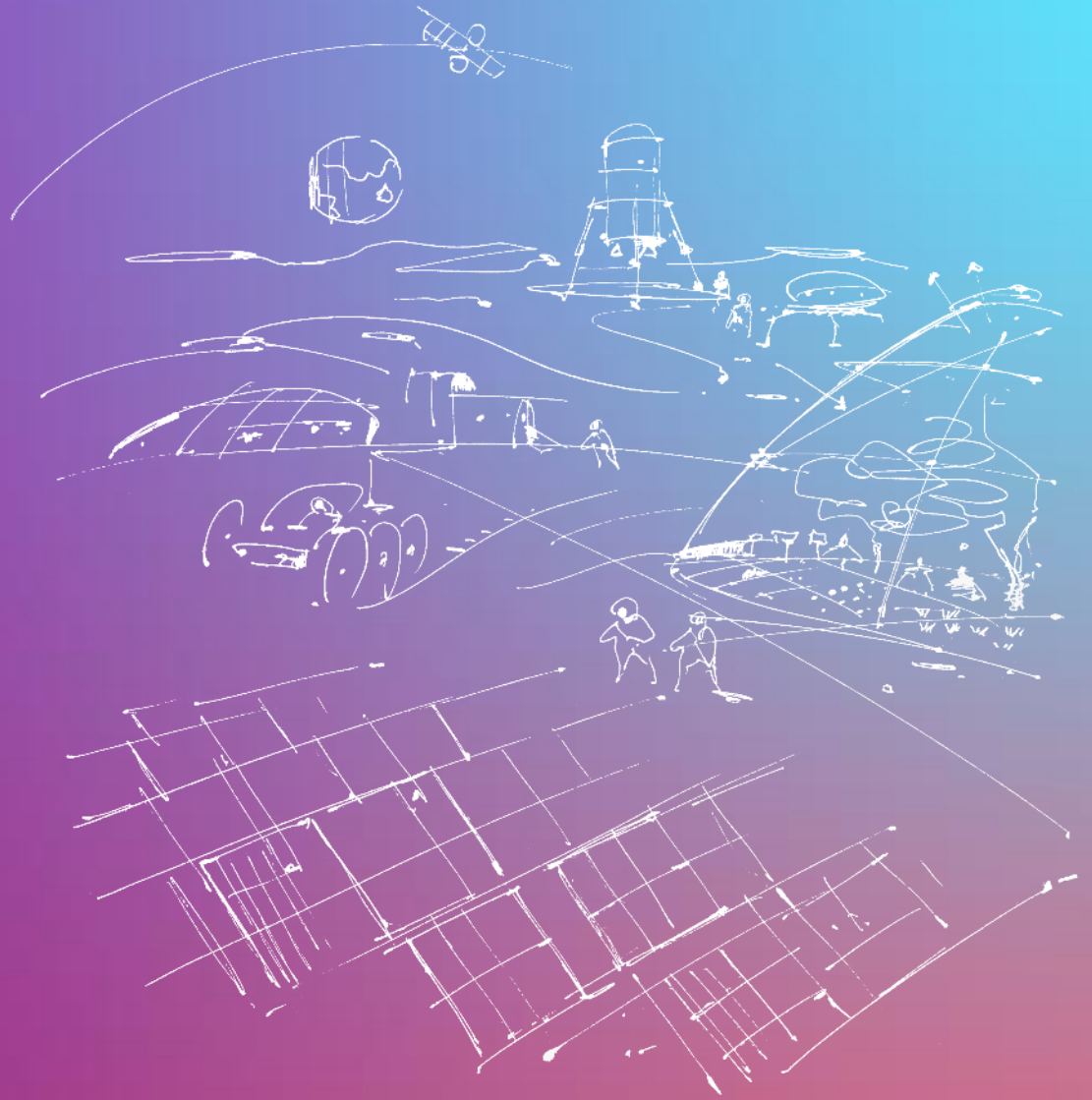


Jacobs

Challenging today.
Reinventing tomorrow.

Relevant Projects

Renewable Microgrid Design and Reference Guide- NAVFAC, USA

Client: US Department of the Navy
Role: Technologist/Owner's Engineer

Jacobs developed a Renewable Microgrid Design and Reference Guide for the Naval Facilities Engineering Command (NAVFAC) as a guide for the Navy to develop its strategy around renewable energy, resiliency, and energy planning. We explored Navy requirements, goals, energy security and other concerns on behalf of NAVFAC.

Topics included:

- Microgrid controls
- Microgrid cybersecurity
- Cybersecurity enclaves
- Project schedule
- Cost impacts
- Other areas

Resilient Cities Challenge USA

Client: Internal innovation competition
Role: Concept Development

In response to an internal competition aimed at innovation for city resiliency, our energy staff developed a concept for a solar- powered electric school bus for emergency response. The school bus would be familiar to communities and with a ~3.5 kW rooftop array, could be deployed to damaged communities to charge cell phone and laptop batteries, and perhaps perform additional tasks, such as portable water delivery or other services.

Permitting Services USA

Client: Confidential Client (Manufacturer)
Role: Permitting and Owner's Engineer

Renewable power is characterized by its fluctuations and unsuitability for base load generation. Grid operators place conditions for the successful integration of large- scale solar and wind power stations to their network. We use in -house resource variability analyses including wind farm ramp rates (particularly at and around cut-out wind speed, but also during wind gust operation) and in-cloud modeling associated with large scale PV systems.

Deakin University Microgrid, Deakin University – Control System Design

Client: Confidential Client (Manufacturer)
Role: Permitting and Owner's Engineer

Jacobs was engaged by Deakin University to design a microgrid to achieve carbon neutral targets by preparing a combined model of their Renewable Energy Microgrid located at the Geelong Waurn Ponds Campus in Victoria, Australia. The Microgrid consists of a 7 MW solar energy farm and a 1 MW/1 MWh storage system, a 0.25-megawatt distributed rooftop solar generation and storage system, and an associated research centre.

Relevant Projects

Off-grid Oil Development, Wyoming

Client: Devon Energy
Role: Owner's Engineer

Jacobs delivered a planning and feasibility study for solar-plus-storage with gas generator backup microgrid at an off-grid water treatment plant site in Wyoming.

Niobrara Energy Park, Colorado

Client: Harrison Resource Corporation
Role: Owner's Engineer

Jacobs worked with Harrison Resources in the development of the Niobrara Data Center Energy Park (NEP), an energy park located on a 644-acre parcel in Weld County, Colorado specifically tailored for data centers, The NEP couples data centers and energy producers on single site for maximum power efficiency and minimization of resource use. The plan includes 300 MW of total data center energy demand and 200 MW combined heat and power power plant, 100 MW PV Solar, and energy storage. Responsibilities included project management, data center design concept development, and microgrid strategy.

Project Study - Off-grid Ready-made Factories, Saudi Arabia

Client: MODON
Role: Owner's Engineer

Jacobs performed a conceptual design of a solar-plus-storage microgrid for new industrial developments in advance of grid connectivity, including creation of specifications for the tender of a power purchase agreement.

The 2 MW load industrial property units called Ready Made Factories would be supplied by a solar photovoltaic energy source, with energy storage and a diesel generator backup source. Renewable energy was to supply at a minimum, 50-percent of the total energy.

Star Peak Renewable Energy Center, Nevada

Client: Star Peak Energy Center
Role: Owner's Engineer

Jacobs designed a sustainable, carbon neutral renewable energy center (+100 MW). The comprehensive plan detailed the site's assets, sustainability initiatives, and a balanced, scalable development of on-site energy uses, power production, energy storage, with net export to the grid. Energy sources included geothermal, solar, and wind with energy storage. Additional responsibilities included the design of a novel high-efficiency data center that was specifically designed to take advantage of site-specific climate, as well as collect and reuse waste heat for co-located agriculture and biofuel industries. The project is the ideal example of the "clean energy economy" and self-reliant regional economies.

Relevant Projects

Athens-Clarke County Public Utilities On-site Solar PV Installation

Dedication of the Solar PV System at Water Reclamation Center

Client: Athens-Clarke County, Georgia, USA
Role: Owners engineer

Project Description

Jacobs conducted a feasibility study for the Athens-Clarke County Public Utilities Department regarding an onsite electricity generation with solar PV at a water reclamation facility. Jacobs developed a conceptual design of a ground mounted, single-axis tracking PV system. The facility's historical utility bills, hourly energy consumption, system capital cost, and generation profiles were analyzed and used to determine optimal system capacity. The final plant was sized at 0.5 MW.

The county proceeded with Jacobs's recommendations for project location and size and our engineering team developed a design bid package to accept Request for Proposals (RFP). The County selected a contractor and construction was completed in early 2019 with Jacobs providing construction oversight.

Challenges and Solutions

This project was challenging in that the current electricity prices were low. Electricity at the facility costs on average $0.048/kWh. Numerous cases were examined to create a scenario where this project could be financially feasible at the electricity rate the facility pays.
Different cases included system size, mounting technology (fixed tilt versus single-axis tracking), and energy sale and financing scenarios. We explored municipal ownership, a power purchase agreement model, and met with the utility Georgia Power to explore alternatives.
The design includes an innovative single-axis tracking system that does not use electric motors.

Wake Island – Solar plus Battery Storage Microgrid

Solar plus Battery Energy Storage System (BESS) for the Wake Island Microgrid

Client: United States Air Force
Role: Owner's Engineer

Project Description

Jacobs completed the design and oversaw the construction and commissioning of a photovoltaic solar array combined with a battery energy storage system at the US Air Force Base on Wake Island, one of the most remote in the Pacific Ocean. The solar plus storage solution was integrated into the base's 4160V distribution system and power plant in order to reduce diesel fuel consumption and engine run times and to enhance reliability and resilience of the power plant. The system was optimized at 750 kW for the PV array and 900 kW/571 kWh for the lithium ion battery energy storage system. The array is designed to withstand hurricane force wind as well as the corrosive, tropical island environment.

Challenges and Solutions

A major challenge for this project site was the footing design for the module support rack. Most module support racks use concrete footings. Concrete is very expensive on Wake Island, so various alternatives were considered including ballasted footing systems. It was determined that helical anchors were the best approach for this installation. Helical anchors eliminate the need for concrete, they are compact for shipping, and installation is fast and efficient.
The project was completed on time and within the budget in 2019.

Relevant Projects

Solar Covered Parking System for Transit sites

Client: Delaware River Port Authority (DRPA)
Role: Owner's Engineer
Cost: $2.5M (Fee) $60M (Construction)

Project Description

Jacobs provided comprehensive services for the development of a large scale renewable energy program for the Delaware River Port Authority(DRPA). The program started with a technical and economic feasibility study to examine the viability of implementing renewable energy projects at thirteen different sites in New Jersey and Pennsylvania that are owned by DRPA. Site infrastructure was surveyed, renewable energy resources were studied, and state regulations on net metering were reviewed. Utility companies were engaged regarding interconnection agreements. Recommendations on solar module technology and balance of plant equipment were provided. Alternative financing strategies and rebates and incentives were included in an economic analysis and financial model. The eight sites offering the best opportunity to implement projects were identified, and seven of those sites are included in the final project.
The next step involved preliminary interconnection applications to reserve the capacity on the utility distribution systems. That was followed by the preparation of an RFQ for the down selection of solar developers for the project as well as an RFP for source selection.
A solar developer was successfully chosen, and Jacobs is currently providing design oversight and construction monitoring services for the project which includes 22MW of solar PV.
The arrays are rooftop, ground mounted and carport canopy type systems. The project will save DRPA over $600,000 per year in electricity costs, and it will provide 50% of the power needed for the entire agency. This includes the power required for 5,000 train trips per month on the commuter line from New Jersey into Philadelphia.

Challenges and Solutions

The solar parking canopies will be constructed with the majority of the parking area still active to allow commuters to still park during construction. Jacobs developed a construction staging and safety plan to protect commuters during construction.

The interconnection to the transit system presented challenges regarding some of the existing DC lines. Jacobs worked with the local utility to develop a detailed interconnection plan.

Southdown Battery Energy Storage System Auckland, New Zealand

Client: Mercury Limited
Role: Owners Engineer

Project Description

In August 2018 Mercury Limited turned the switch on New Zealand's first transmission grid-connected batter energy storage system (BESS) at its Southdown power station in South Auckland, NZ. The power station site was home to a mothballed 130 MW natural gas fired cogeneration station and had a connection to the 220 kV national electric grid. The 1 MW/2 MWh BESS is a research and development project intended to determine how flexible and efficient battery storage can be used in conjunction with Mercury's renewable rangy portfolio.
Jacobs was engaged by Mercury Limited in 2017 to undertake a prefeasibility study and support the preparation of a business case for the interconnection of a 1 MW scale lithium ion battery system. The study included grid connection analyses, BESS supplier requests for information, budget cost estimates, communication integration, grid compliance, fault level and harmonic level assessments, and fire protection studies.
Following Mercury Board approval, Jacobs was engaged to provide technical sup.port during engineering design, procurement and construction phases. The project capital cost was NZD $3 million

Challenges and Solutions

During the prefeasibility study the key challenges included:

- Assessing and identifying a suitable location for the BESS either inside or outside the existing power station
- Confirming whether the existing internal 11 kV network was in good working order and suitable for connection of the new BESS

During the feasibility study and construction phase, key challenges included:

- Presence of buried asbestos in proposed BESS locations. Jacobs provided careful design of the foundations and above ground cable tray for routing the 11 kV cables to the BESS.

The project benefited from end-to-end involvement of Jacob's strategic advisory and power team from prefeasibility through the construction phase. The allowed identification of risks and potential solution and ensured alignment with Mercury's overall objectives. The client benefited from a successful delivery of a fully integrated grid-connected BESS system on time and budget. Mercury can now test and evaluate the BESS ahead of committing to a larger scale BESS deployment in the future.

Microgrid Clemson University

Designed and implemented a solution to update a 1970s electrical system into **a modern microgrid with high-capacity, self-healing grid topology** to meet the resilience needs of this Tier 1 research university.

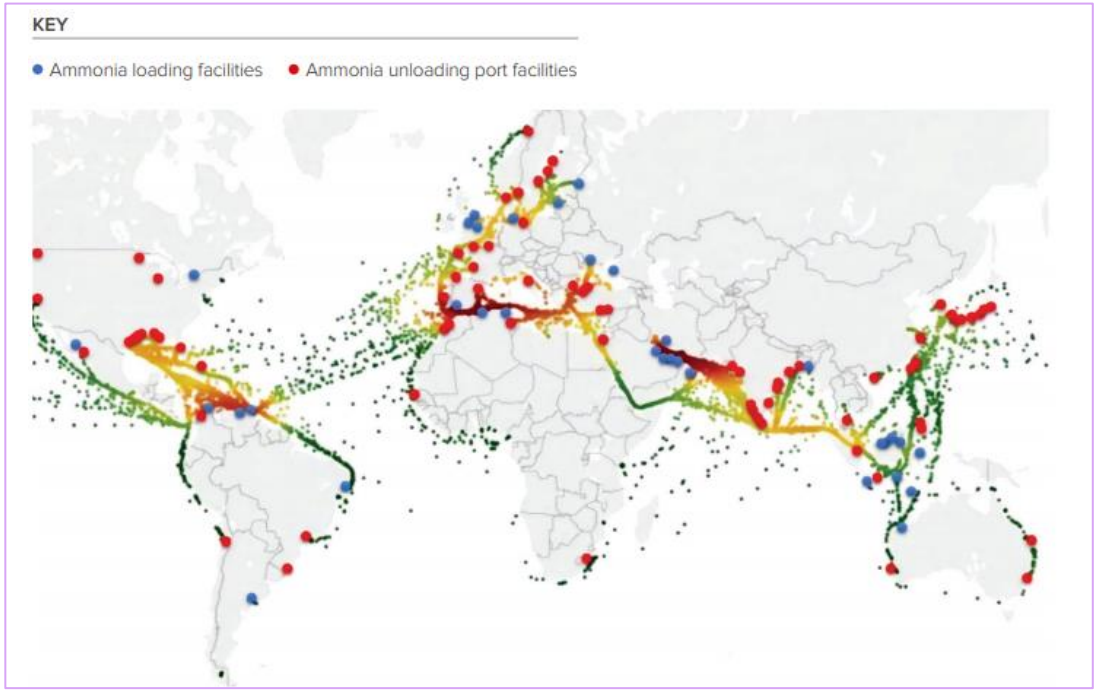
Microgrid New Jersey TRANSITGRID

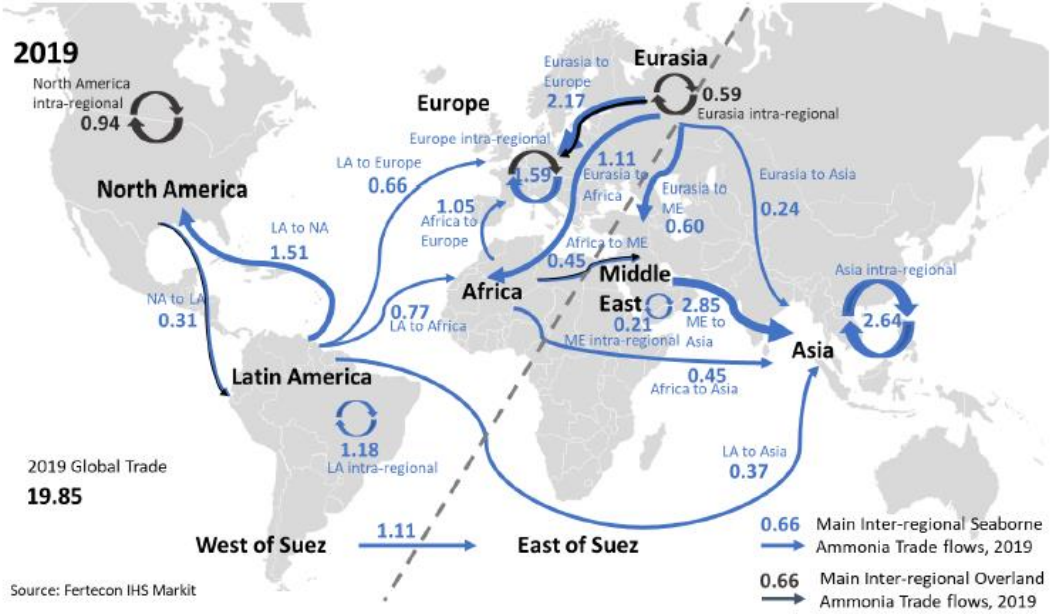
First-of-its-kind microgrid capable of providing reliable power for critical transit infrastructure supporting vital rail systems, with capability to provide 140 MW of highly resilient power

Ammonia Supply Chain

- **188 MTPA Produced**
  - 18 MTPA traded on open waters
- Blending opportunities to meet required price points of offtakers
  - Pure green H2 to NH3 is currently approx. $700 USD/ton at small scale
  - Market price: $220 but potential Japan acceptance: $380…?
- **JERA demand stated as:**
  - 30,000-40,000 mt of ammonia by 2024-25 (April-March),
    - Starts 20% co-firing at its No. 4 1 GW coal-fired unit at Hekinan
  - 2030 3 million mt/year of fuel ammonia, or equivalent to 500,000 mt/year of hydrogen
  - 1 GW coal-fired power plant would need about 500,000 mt/year of ammonia for 20% co-burning, meaning 3 million mt/year of ammonia consumption would require six 1 GW coal-fired units
  - JERA aims to start using 100% ammonia as a fuel in the 2040
- **Japan has estimated its demand for fuel ammonia in the power and shipping sectors to be 30 million mt/year in 2050**

Source: The Royal Society, 2020, Ammonia: zero-carbon fertiliser, fuel and energy store





obs 2020

Hydrogen or Ammonia as a Fuel for Gas Turbines

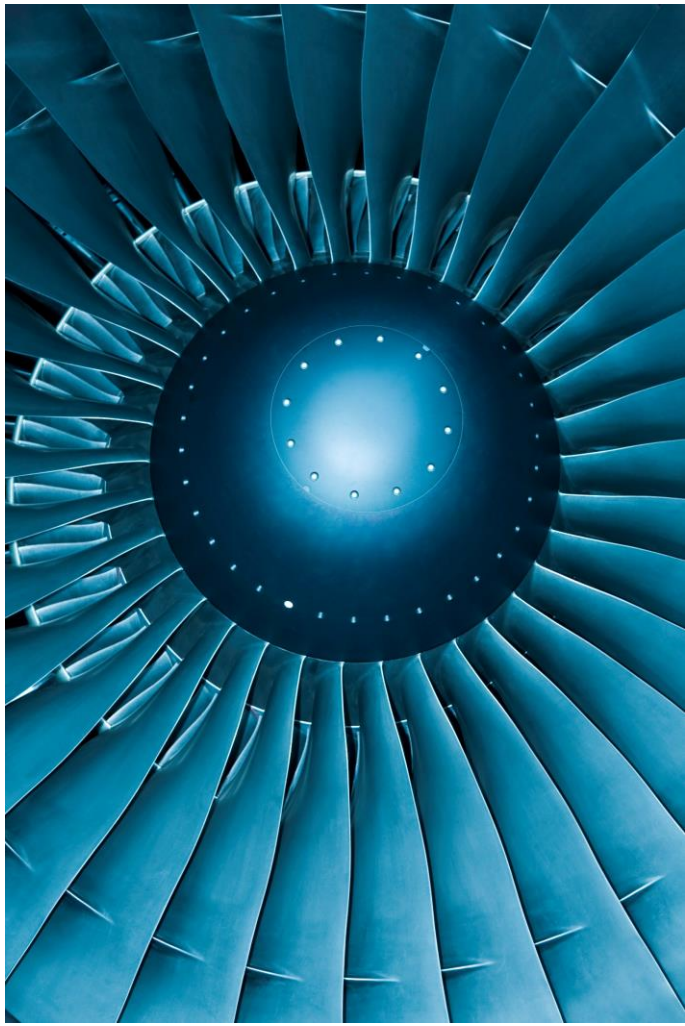
- All major OEMs have development programs
- More experience with Hydrogen, and almost mature for Natural Gas/H2 mixtures to 30%
- Ammonia may offer better long-term solution for utility scale – by 2040/2050 unless LH2 takes off

HYDROGEN

- Currently, use of Hydrogen is more advanced than use of Ammonia – targeting 100% by 2030
- OEMs gained some experience with Hydrogen from earlier IGCC projects
- Volume required for utility scale generation is large (3* NG)
- Hydrogen may be better used for other higher value applications – e.g. fuel cells for transport

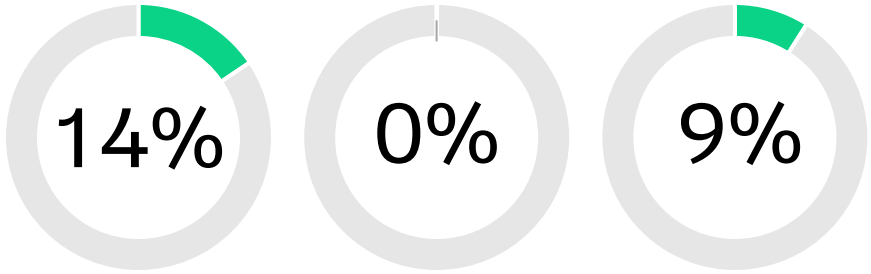
AMMONIA

- Very little actual experience – Mid TRL at utility scale
- More significant changes to combustion systems required and safety/toxicity issues
- High NOx emissions but can add SCR system in HRSG



Micro-Grid Master Planning

Environmental Stewardship



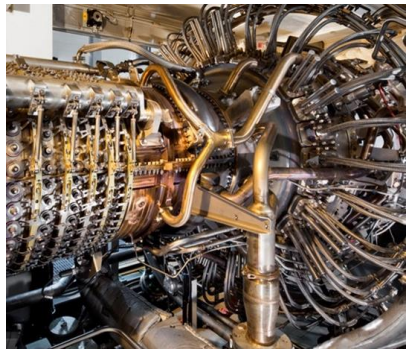
Energy Reduction | Water Conservation | GHG Reduction

- Condition assessment
- System modeling
- Load growth projections
- Infrastructure renewal
- Energy efficiency upgrades
- Self-generation / fuel diversity evaluations
- Distribution analysis
- Environmental strategies
- Plant siting
- Reliability improvements
- Economic analysis
- Cost estimating
- Funding/phasing/scheduling

Power Generation

- Initial feasibility
- Advanced planning
- Detailed economic evaluation
- Fuel studies & sources
- Cycle optimization
- Equipment procurement
- Full-service design
- Environmental permitting
- Noise abatement
- Relaying/grid synchronization
- Blackstart coordination & design
- Commissioning
- Operator training

Microgrid/Smart Grid



- Smart grid master planning
- Microgrid feasibility
- Generation capacity & availability analysis
- Energy security analysis
- Generation diversification
- Emergency power
- SCADA & intelligent system control design
- Energy optimization
- Utility interconnection coordination

Electrical Distribution

- Reliability assessments
- Power factor correction
- Relay coordination
- Short circuit analysis
- System modeling
- Substation design
- Grounding system design
- UPS system design
- Emergency power
- Black start power
- Rate analysis

Energy Management

- Field surveys & audits
- Energy analysis
- Computer energy simulations / modeling
- Life cycle cost evaluations & rate studies
- Energy monitoring & controls upgrades
- Lighting & steam trap retrofits
- HVAC & plant retrofits
- LEED certification & energy star buildings
- Water conservation
- Project financing & ESPC reviews
- Investment grade audits
- Retro-commissioning