Hybrid Power Solutions
Portfolio Presentation

September 2022
Demographic change

Climate change are drastically changing our environment.

Globalization

Urbanization

Digitalization
At the same time, we expect a **25% increase** in global energy demand by 2040.

This will present **enormous challenges** for the environment.
The challenges are many

- facing changing requirements by regulations and customer expectations
- ensuring energy availability by a broader grid independency
- securing future for production sites by ensuring optimized OPEX

but the solution is powerfully simple
Hybrid Power Solutions

the power to decarbonize is yours
Hybrid power solutions leverages various potentials...

- the combination with existing assets
- the easy-made control of complex energy systems
- the integration of renewables
… and enables us to integrate multiple technologies to one optimized energy system ...

### Renewables
- Wind Off-/Onshore
- Solar PV
- Solar CSP (ST)
- Hydro
- Biomass-Waste (ST)
- Geothermal (ST)

### Thermal
- Gas (Gas turbine, Steam Turbine, RICE)
- $\text{H}_2$ (Gas turbine, Steam Turbine, RICE, Fuel Cells)

### Storage Technology

#### BESS/Electrochemical
- Li-Ion Batteries (SIESTART, etc.)
- Flow Batteries (Vanadium Redox)

#### Mechanical Storage
- Pumped Hydro
- Compressed Air Energy Storage (CAES)
- Liquid Air Energy Storage (LAES)

#### Chemical Storage (incl. Fuel Cell)
- Hydrogen/Power-to-fuel (Silyzer)/Fuel Cell

#### Electrical Storage
- Capacitors (FACTS)

#### Thermal Storage
- High-temp. sensible heat (incl. Molten, Salt, Concrete/Energy Nest, Stones/ETES)
- Low-temp. sens. Heat (Hot/Cold Water)

1 Short-term storage only
... for increasing flexibility and adaption to market needs

Renewables generation

- Zero emissions
- Sustainable

... but not reliable

Gas-fired power generation

- Dispatchable
- Reliable output

... but not sustainable

Energy Storage

- Instant output
- Dispatchable
- Zero emissions

... but not continuous
With **Hybrid power solutions** as decarbonized energy system you are…

**Powerfully independent**
for your remote location or in case you have limited access to grid

**Powerfully profitable**
by reduction of OPEX and LCoE, to secure the competitiveness of your production site

**Powerfully sustainable**
by meeting your decarbonization targets in an increasingly complex energy market

**Powerfully reliable**
with higher availability on energy generation to increase grid availability & reliability
...able to benefit along the complete value chain

- **Broad Portfolio**
  elements can be implemented, either inhouse or as third-party supply

- **Hybrid Control System**
  as microgrid brain enables controllability of complex energy systems

- **Integrated solutions**
  leverage the strengths of different technologies

- **Reliable Partner**
  for developing the best-fitted hybrid power solution

- **Technology Leadership**
  especially on inhouse portfolio elements leads to an optimized solution

- **Operational Excellence**
  in various project types and sizes

- **Holistic approach**
  considers all aspect throughout the complete project lifecycle
Hybrid power solutions address various market segments with a customized and decarbonized solution.
Co-creating your hybrid power solutions starts with your needs and our value proposition to...

...create the best fitted energy solution for any specific customer application

...display the efficient maximization of renewable energy sources

...integrate existing assets in the overall energy management system / microgrid

Energy System Design

Technology related input data
- Performance models and parameters
- Component cost models

Site specific input data
- Optimization objective
- Load profiles
- Commodity prices
- Renewable generation profiles
- Climate/weather data
- Technology pre-selection

Energy System Design

Selection
- [...] examples

sizing, and
- [...] example

... (economic) dispatch of technologies

Results (output data)
- Technology selection
- Optimal capacities
- Optimal operation schedule
- Economical and ecological data

2022-09 Siemens Energy is a trademark licensed by Siemens AG.
… find the right combination for leveraging the different strengths of each technology
Hybrid power solutions using modern control systems for simplified and flexible operation

- Suited for all types of systems – easily integrating different technologies across an entire system
- Enhanced plant reliability – allowing data to be collected in real time to identify and react more efficiently
- Improved performance – innovations that provide the right tools for flexibility and maximized capabilities
as the hybrid control system is the microgrid brain

Per definition and standards, **microgrids** are entities which manage their own **decentralized** power production and consumption and are capable of **island operation mode**.

Depending on the business case, many microgrids, always run in **on-grid mode**.

Managing a microgrid with multiple different decentralized resources requires a **hybrid microgrid controller** to provide automated and at the same time optimal operation for the customer.
Omnivise Hybrid Control combines all elements in 1 system

<table>
<thead>
<tr>
<th>T3000 Microgrid Controller</th>
<th>SCADA Application Server</th>
<th>Dispatch Optimizer</th>
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<tbody>
<tr>
<td>Manages all assets in real time. With integrated microgrid control functions, automated 24/7 operation is provided.</td>
<td>Provides SCADA functions for monitoring and engineering of a microgrid, enabling the operator full overview and control.</td>
<td>Calculates an optimal economic dispatch based on load and generation forecasts, as well as financial and technical params.</td>
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Modbus TCP/RTU, DNP 3.0, OPC UA, Profinet, IEC61850…

PV installation
Storage
Diesel / Gas / CHP
H₂, Electrolyzer Storage, FuelCell
Hydropower plant
Wind
GT, ST or CCPP
Consumer, i.e., industry
GRID
O&M for Hybrid Power Solutions save OPEX by our Integrated Service Concept across all systems

Synergies in Operation
Lean operations team for all systems

Synergies in Maintenance
Multi skilled personnel for highest service efficiency

Synergies in Spare Parts Management and warehousing

Remote Operation
for low manned / unmanned operation

Harmonized Maintenance Management System incl. CMMS software

24/7 Remote Expert Support for trouble shooting, operation and maintenance

Integrated O&M

Conventional

Solar

Wind

H₂ Storage

Heat
Combining the developments in Remote Services, Automation and Digitalization by the changes in workforce and the energy transition enables...

**Autonomous Operation**
The step further of remote operation

- **Lower CAPEX**
  Centralized manning

- **Business Continuity**
  Keep the lights on

- **Safety**
  Achieving Zero Harm

- **Higher Availability**
  Less unplanned downtimes
Omnivise Asset Management (OAM) enabling your journey to autonomous operation

Digital Customer Journey

Digitalization

1. Introducing RCM and knowledge (e.g., FMEA)
2. Digitizing (Inside) Operations (logging, task planning)
3. Digitizing maintenance (WR, WO, execution)
4. Increasing Automation for L2 (black box integration)
5. Digitizing Diagnostic Workflow and beyond
6. Increasing Automation for L3/ L4 (cameras)
7. Supporting mobile teams
8. Expanding to Remote Control
9. Introducing (Outside) Operation Rounds / Mobile Support
10. Automating operations (automated logs, image analytics)
11. Increasing Automation for L3/ L4 (cameras)
12. Automating Diagnostics
13. Increasing Automation for L3/ L4 (cameras)
15. Automating maintenance (prioritization, inspection)

Automation
Zero Carbon Hybrid Power Plant
saving 39,000 t/a CO2

Customer Challenge/Driver
Developing zero carbon hybrid power plant for decarbonization of current energy generation and becoming independent from fossil fuel supply.

Portfolio Elements
• Solar
• Fuel Cell
• Battery Storage
• Electrolyzer

Scope
• Joined project development
• Establishing of best energy generation scenario including daily forecast
• EPC turnkey with LTSA

Customer Benefit
• Decarbonization of existing energy supply
• Achieve low electricity costs by sustainable power generation
• Develop partnership for further decarbonization projects
• High Quality on execution concept and integration capabilities
• Gaining independency for fossil fuel supply
supplies 10,000 households around the clock with green energy

saves 39,000 tons of CO2 yearly

128 MWh storage in Battery and H₂
Zero Carbon Hybrid Power Plant Layout
Zero Emission Hydrogen Turbine Center (ZEHTC)

**PROJECT TYPE**
Hybrid solution

**Challenge / Driver**
Showcasing a solution for future energy system and the integration of gas turbine technology by decarbonization of gas turbine test facility. Setting up a demonstration plant with a flexible and sustainable energy system connecting gas turbines with hydrogen, renewable energy and energy storage.

**Portfolio Elements**
- Solar panels and battery storage
- Electrolyzer
- Hydrogen Storage
- Integration with gas turbine testing center

**Scope**
- Joined project development within a consortium of six partners from the private and public sectors including two international universities. Funding is supported by EU via Era Net SES.

**Benefit**
- \( \text{H}_2 \) production from excess power from gas turbines test and renewables
- Decreased \( \text{CO}_2 \) emission from the testing facility
- Building expertise about sustainable energy systems and hybrid solutions
- Optimized use of power during test run
- Reduction of liquified natural gas (LNG) use and transportation thanks to local production of hydrogen
- Support hydrogen combustor development
Reference Hybrid Solutions

American Naval Station: Largest Energy Savings Performance Contract in Department of Defense

- Whole base solution providing energy resiliency, reliability and efficiency
- Liquefied natural gas (LNG) as primary fuel source
- LNG procured through Defense Logistics Agency (DLA)
- Cyber secure architecture
- Renewable energy – Photovoltaics, battery storage, and monitoring of the existing wind turbines
- Dual fuel capability providing resilience of supply
- Microgrid management system connecting together the installation’s power generation
- Enhanced maintenance, repair and replacement paid for through guaranteed savings
Within the objective of Ecuador’s "Zero Fossil Fuel Initiative for the Galapagos Islands" a new hybrid power generation system was installed in Isabela island located in the Galapagos Archipelago. It is successfully in operation since October 2018.

Siemens Energy implemented a 952 kWp photovoltaic system, a battery storage system with an output of up to 660 kW and a power generation plant with a total output of 1625 kW.
Use Case
Mining Application

Customer Challenge/Driver
Decarbonization of mining operations by integration of renewable technology with 24/7/365 reliable power supply.

Portfolio Elements
• Solar
• Wind
• Battery Storage
• Gas turbine (new built/existing assets)

Scope
• Joined project development
• Supply of portfolio elements
• Integration of new technologies and existing assets
• Construction and Commissioning

Customer Benefit
• Decarbonization of existing power supply
• Achieve low electricity costs by sustainable power generation
• Develop partnership for further decarbonization
• Integration of gas turbines as reliable power supply
• High Quality on execution concept and integration capabilities
Use Case

Sugar factory
an example for industrial application

Current situation
❖ Customer builds sugar factory and sugar beet farm with electricity demand >100 MWel
❖ Process steam demand >100 MWth currently planned to be covered by gas fired boilers

Development goal
❖ Develop hybrid power plant to reduce the costs of electricity – currently the grid tariff

Boundary conditions
❖ Wide land use for PV and wind turbines
❖ Natural gas grid connection available

Idea
❖ Develop an optimized hybrid energy system consisting of renewables (PV & wind turbines) and fossil backup (e.g. gas turbine or combined cycle power plant)
❖ Demonstrate synergies to provide the required process steam as side product from fossil backup
❖ Perform analysis by Energy System Design to consider a wide range of energy systems including storage solutions

LCoE shown here are illustrative figures based on typical EPC prices for subsystems only.

Optimum energy system allows reduction of LCoE (electricity and steam) by ~25% and reduction of CO₂ emissions by ~60%

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Island energy generation

**Customer Challenge/Driver**
Utilization of renewable power generation for decarbonization of energy landscape by ensuring grid availability and integration of various technologies.

**Portfolio Elements**
- Solar
- Wind
- Battery Storage
- Recips
- Electrolyzer

**Scope**
- Joined project development including setting best fitting technologies sizes
- Establishing of best energy generation scenario including daily forecast
- Integration of new technologies and existing assets
- Construction and Commissioning

**Customer Benefit**
- Cost efficient power generation of sustainable and green energy
- Stable power supply due to storage solutions
- Less fuel dependency
- Use existing thermal assets as back-up for microgrid stability
Leveraging possibility for coupling with existing and developing energy sectors

Possible scenarios for sector coupling
Use Case

Low Carbon Hybrid Power Plant for CO₂-free city

- Renewable Energy
- Fluctuating generation
- Energy conversion
- Battery
- Grid stabilization
- Grid
- Sector coupling
- Gas turbine
- Steam turbine
- Energy Storage
- Re-electrification
- Hydrogen
- Thermal
- Heat
- Thermal conversion
- Battery
- Grid stabilization
- Grid
Keeping in mind **Hybrid Power Solutions**

**Powerfully decarbonize**
Utilization of renewable energy generation for lower CO₂ emission

**with a Holistic project approach**
Developing, designing and executing your idea to co-create the best energy system

**Powerfully intelligent**
Implementation of various technologies to one energy system
Lets get in touch

Hans Koopman
Business Development
Hybrid Power Solution

SE GP G SO DSC DS HS
Mobile +49 173 6939692
E-mail hans.koopman@siemens-energy.com

Mario Hueffer
Business Development
Hybrid Power Solutions

SE GP G S DES CI
Mobile +49 152 01808708
E-mail mario.hueffer@siemens-energy.com

or visit us on our webpage: Hybrid Power Solutions
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