ETES –
2nd Life Option for Fossil Power Plants

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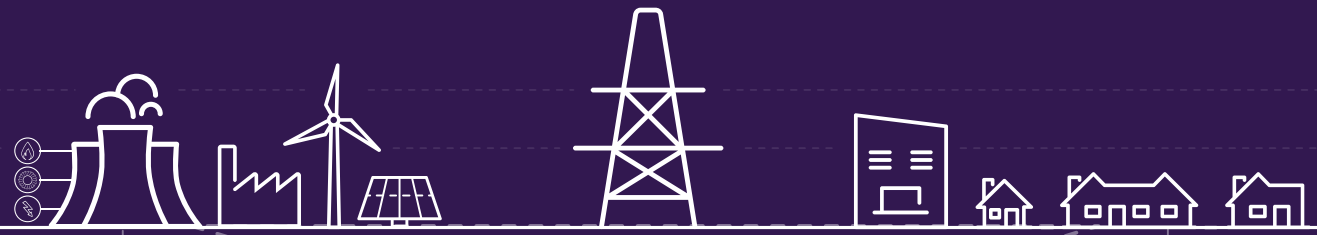
Decarbonization challenges



COAL PHASE-OUT

Maintain asset value

Offer a 2nd life for existing assets by substituting fossil fuels

Security of supply

Provide backup power in case of low RE generation

STORAGE

New business models

Embrace the energy transition and tap new revenue streams in a changing business environment

Flexibility of power generation

Covering increasing flexibility requirements for fossil power plants due to growing share of RE

Utilities need a storage solution that is

Versatile

Broad field of applications

Scalable

Doubling the size without doubling the cost

Clean and Safe

Environmentally safe materials and supply chain

Geographically Unrestrictive

Can be built anywhere in the world

Low Cost

Abundantly available and cheap storage materials

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ETES' reliable working principle

Charge

- Low price electricity is converted with conventional equipment to heat during charging
- Alternatively direct charging with heat possible as well

Store

- Volcanic rocks are used as a storage medium
- Heat storage is operated close to am-bient pressure & at high temperature
- Heat is stored up to weeks

Discharge

- Discharged heat is converted to electricity in water steam cycle
- Alternatively, direct use of heat and process steam possible

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Conversion of coal power plants to emission-free storage plants

Coal-fired Power Plant

Power plant based 100% on coal combustion

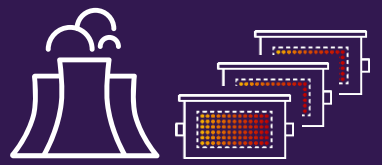
- High CO_2 emissions related to fossil fuels
- Facing the shutdown due to strong restrictions and coal phase-out
- Political pressure forces plant operators to innovate and decarbonize
- Declining profitability due to limited operational flexibility in an ever more fluctuating energy market

Hybrid Storage Power Plant

Partial conversion into storage plant

- Installation of ETES storage parallel to existing fossil firing
- Integrate renewable energies and reduce CO_2 emissions
- Evaluate technical and commercial operation for future scale-up
- Integrate energy storage into company portfolio
- Increase flexibility to follow increasingly challenging market requirements

Emission-free Storage Power Plant



Full conversion into storage plant

- Complete decommissioning of combustion equipment
- 100% of the steam coming from ETES
- Leverage full technical and economic potential of existing infrastructure
- Avoid emission-related operational cost
- Manage fluctuating renewable energies and complete the energy transition

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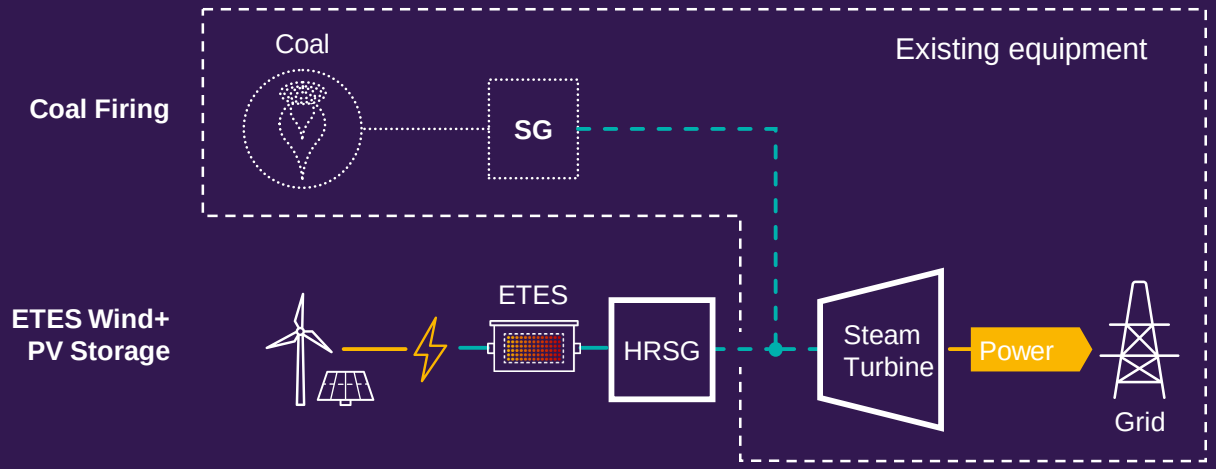
Customer use case – Partial conversion of coal power plant to CO_2-free storage plant



Electrical charging power: **140 MW_{el}**

Discharging power: **140 MW_{th}**

Thermal storage capacity: **1.4 GWh_{th}**

Cycle times for charging/ discharging: **10 h/10 h**

- Dual-use of equipment: Steam and condensate systems, switch yard, control system; as well as trained staff
- Direct charging from renewable energies (PV + wind)
- Time-shifting of several hours to optimize revenues from electricity generation
- ETES discharges high-pressure superheated steam for re-electrification in existing steam turbine

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ETES track record

Technology Development Since 2011

2014

2019

2021

Test Site

- Small-scale demonstrator in Hamburg Bergedorf with **5 MWh storage** capacity
- Testing of various storage concepts, materials and setups
- Over 2,500 testing hours per storage module

Demonstrator

- Demonstrator with a capacity **of 130 MWh** stored in volcanic rocks
- **5.4 MW** resistive heating charging power
- Inauguration and connection to the Hamburg grid in June 2019
- Biggest German public funded storage R&D project

Commercial Pilot

- We are currently working with world-class partners on various projects around the world in order to build the first series of commercial pilots in a range of
  - Power: 10 – 100 MW
  - Capacity: 100 – 2,000 MWh
  - Steam temperature: 300 – 620°C

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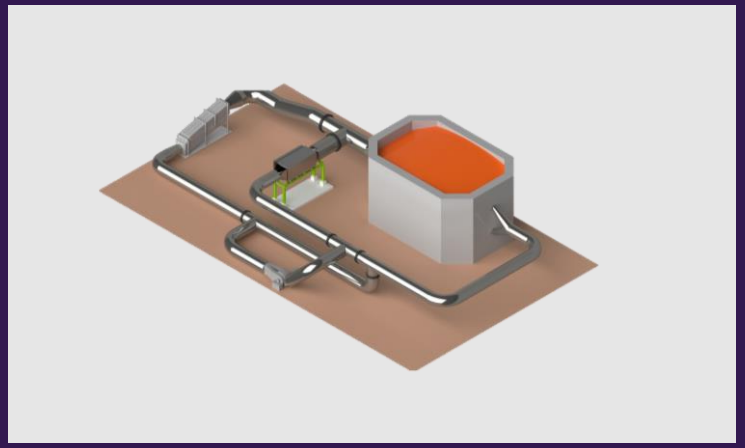
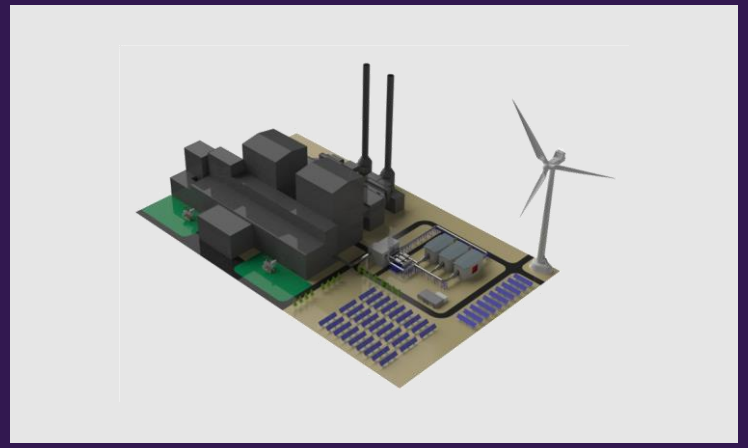
How the ETES team can support you





Individual assessment

Customer-specific advice through

- Technical workshops with our experts
- Analysis of potential applications and identification of the best use case
- First technical sizing and commercial evaluation

Full feasibility study

Joint working group for

- In-depth analysis of the previously defined use case
- Conceptual engineering and business case calculation
- Basis for decision making

Project realization

Dedicated project team for

- Project Management
- Basic and detailed engineering
- Erection and commissioning of the storage plant

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Mature and Ready

ETES is based on **80% existing** and mature technologies and has been validated in **130 MWh/5.4 MW** demonstration plant.

Adaptable and Flexible

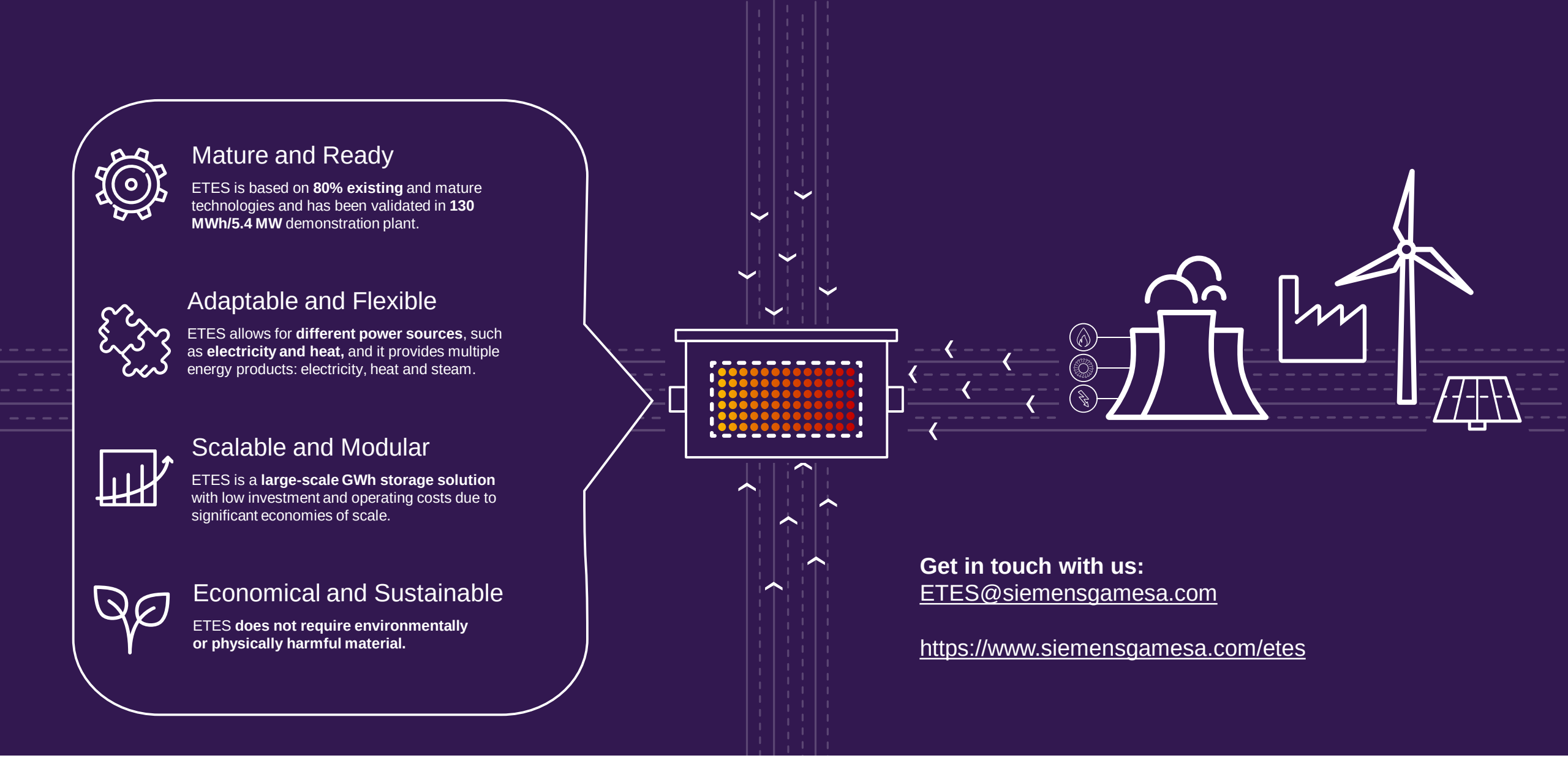
ETES allows for **different power sources**, such as **electricity and heat,** and it provides multiple energy products: electricity, heat and steam.

Scalable and Modular

ETES is a **large-scale GWh storage solution** with low investment and operating costs due to significant economies of scale.

Economical and Sustainable

ETES **does not require environmentally or physically harmful material.**



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ETES Recognitions

2018

La Razon Sustainable Technology Award

Award for continuous renewal of imagination, creativity, knowledge, skills and processes

2019

Best Innovation in Offshore Energy

Award to highlight the best innovation in the entire offshore energy market

Japanese Government/ICEF

Award for recent innovative developments in energy and climate change mitigation

2020

R&D 100 Award

The R&D Award honors the greatest R&D pioneers and their revolutionary ideas in science and technology

SDG Tech Award

The SDG Tech Award highlights the best sustainability solutions in Denmark

Solar and Storage Award

The Solar and Storage Award highlights the best product innovations for solar and storage solutions

Power Technology Excellence Awards

The Power Technology Excellence Awards celebrates the greatest achievements and innovations in the power industry.