MAY 2022

Using large electric motor technology to help industry move toward greater decarbonization

Motors from the world’s leading supplier

What will we cover today?

- Electric motor's role in industry
- ABB Synchronous Motor Types
- Electrification
- Top Industrial Efficiency initiative
- Grid stability using synchronous condensers

Steve Barrass
Market Development Manager NAM
Synchronous Machines


ABB Purpose
We enable a low-carbon society
We reach carbon neutrality in our operations by 2030 and partner with our customers and suppliers to reduce their emissions.
Integrity
We promote social progress
We take care of our people and promote social progress with our partners, suppliers and in communities.
Transparency
We preserve resources
We embed circularity by reducing waste, improving recycling and fostering reusability.

Insight into Carbon Capture

CO_2 and CCS in numbers

30.6 Gt	40 Mt	38 pcs	7.6 Gt	1.5 C
Total amount of CO_2 emitted in 2020	Total amount of CO_2 captured in 2020	Total number of CCS facilities in 2020	Estimated amount required captured before 2050	The targeted temperature rise since industrial revolution

The critical role of motors

- 45% of the world's electricity is used to power electric motors systems in building and industrial applications
- By 2040 the number of motors will have doubled
- Investing to upgrade the equipment used in these systems will yield significant rewards in terms of efficiency and sustainability

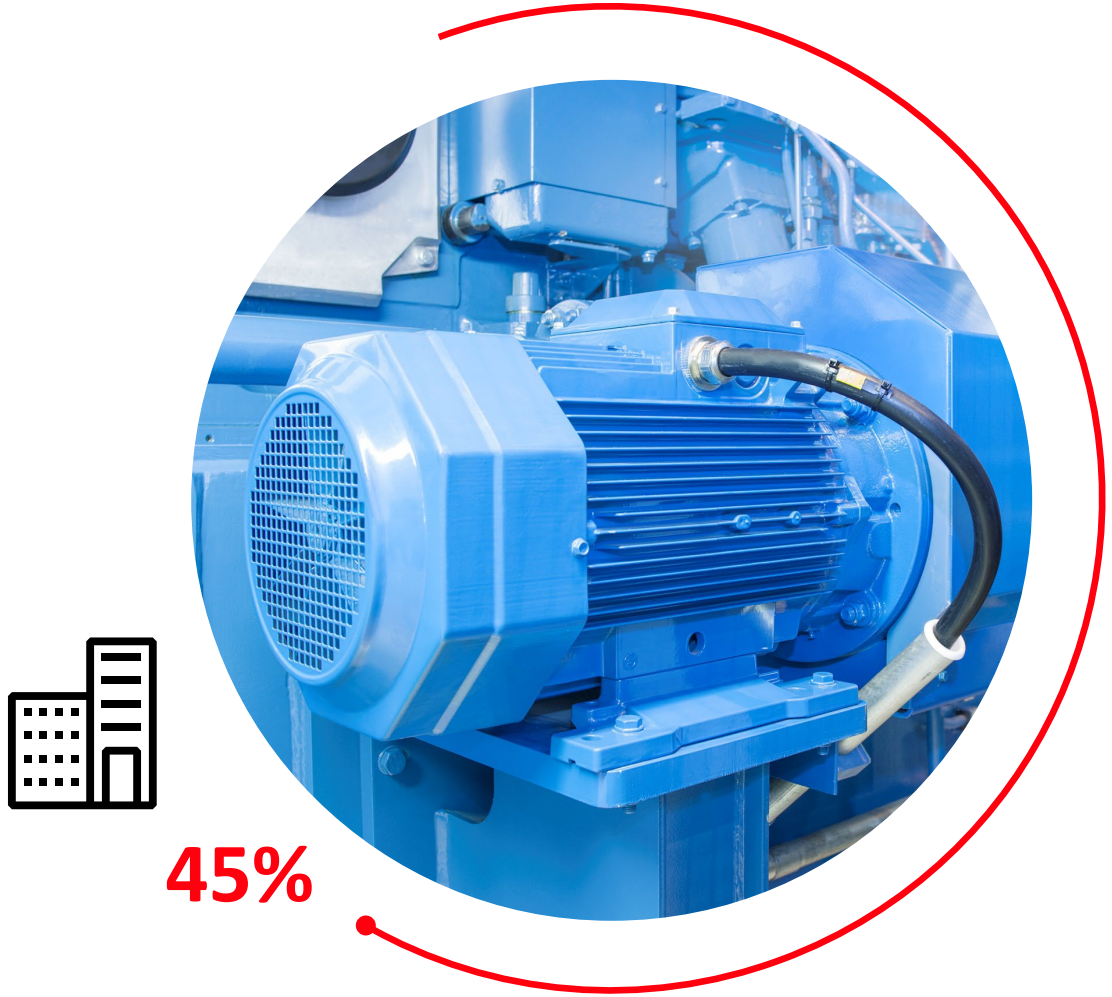


ABB Synchronous Products

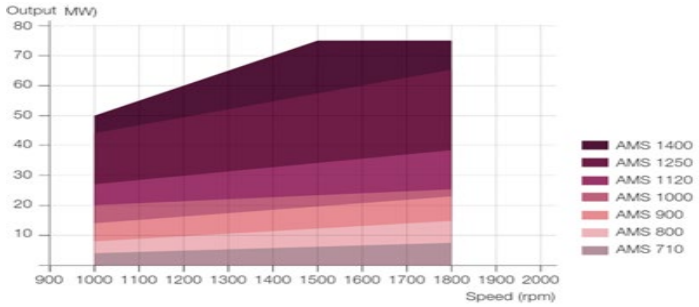
Synchronous Machines for today's discussion

AMS Synchronous Motors

Product:
- Type: AMS 710 - 1400
- Poles: 4 - 6
- Power: 1 – 75 MW
- Voltage: 1 – 15 kV
- Speeds: 1000 – 1,800 rpm

Applications:
- Compressor, Pump, Extruder, Refiner
- DOL and VSD

Industries:
- Petrochemical, O&G, Metals, P&P
- Air-separation

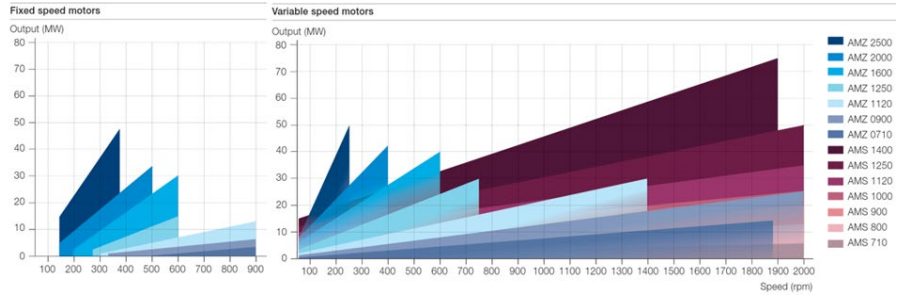


AMZ Synchronous Motors

Product:
- Type: AMZ 710 - 2500
- Poles: 8 - 40
- Power: 1 – 60 MW
- Voltage: 1 – 15 kV
- Speeds: 20 – 1,800 rpm

Applications:
- Compressor, Pump, Hoist, Mill, Conveyor, Extruder…
- DOL and VSD

Industries:
- Petrochemical, Mining, O&G, Metals, Marine, P&P

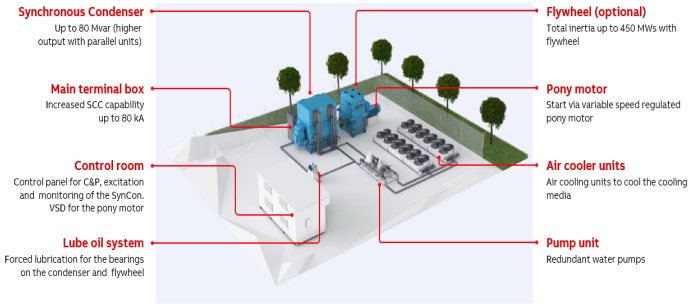


AMS Condensers

Product:
- Type: AMS 710-1400 + FW
- Poled: 4-6
- Power: 1 – 80Mvar
- Voltage: 1 – 15 kV
- Speed: 1000 – 1,800 rpm

Application:
- Grid stability

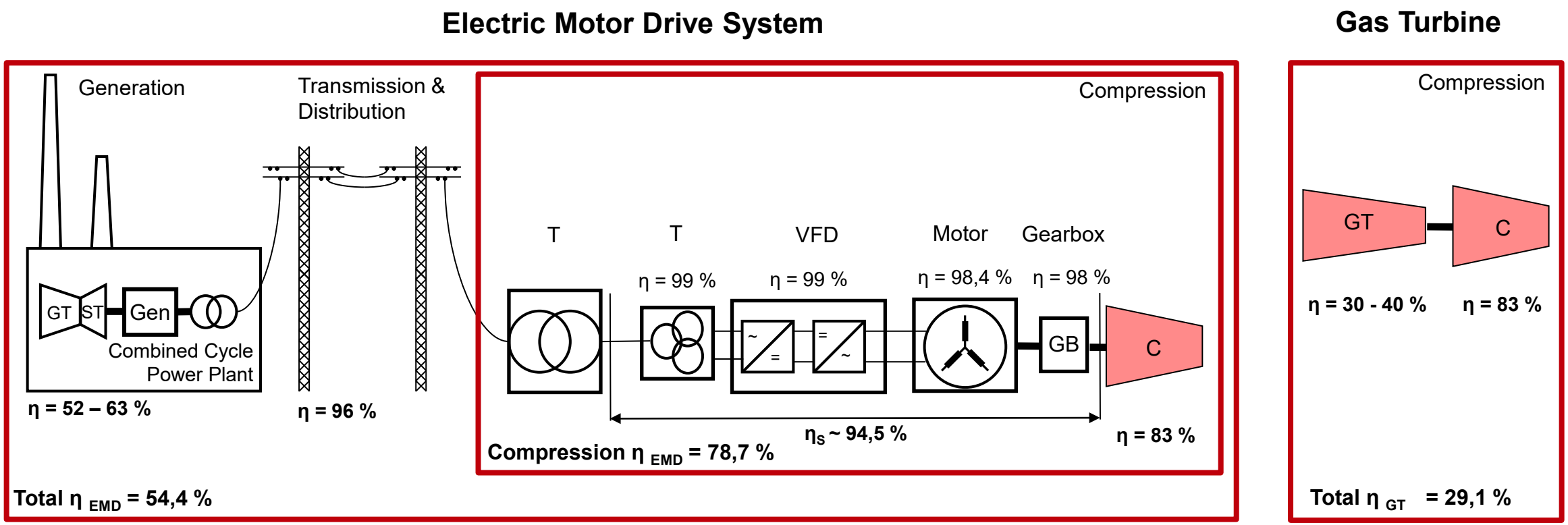
Industry:
- Power gen, mining, etc



Electrification

Electrification using large electric motors

What to consider - Total efficiency perspective



Electrification using large electric motors

Benefits of Change

Prior to Replacement

- Lower efficiency
  - Efficiency dependent of ambient temperature
- CO2 – NOx emissions
- Time consuming start & stop process
- Greater downtime, resulting in lower availability
- High maintenance effort (time consuming, expensive)

New Driver Installed

- High efficiency drive train
  - Efficiency almost independent of ambient temperature
- No CO2 - NOx emission of the drive train
- Fast start & stops (starting under load possible)
- Minor maintenance to be followed
- Increase availability & reliability
- Wider operating speed range – configuration dependent
- Reduced footprint
- Lifetime expansion (Digital tools - remote monitoring and condition based monitoring, drive train analytics)

Electrification using large electric motors

Benefits of Change

	Unit		Gas Turbine Drive	Electrical System
Impact on the Environment at site			high, larger emissions of heat and gases	very low, little heat dissipation; no other emissions
Reliability	%	Average over 5 y	~ 97	➢ 99
Availability	%	Average over 5 y	~ 96	➢ 99
Efficiency full load	%	60 - 100 output	30 – 40	95 - 97
Influence of Ambient Temperature	°C		power rating drops if site temperature rises > 15°	power rating constant at all site temperatures
Operating speed range	%	of rated speed	90 - 105	60 – 105
Start-up restrictions	in minutes	cold warm	first start after around 20 re-start after ca. 180	immediate first start immediate re-start & stop
Planned Maintenance Time:	Shutdown / days	every year	14	2
Planned Overhaul Time:	Shutdown / days	every 5 years	14 – 21	none
Expected / Design Lifetime	years	Maintenance dependent	15 – 25	25 - 30

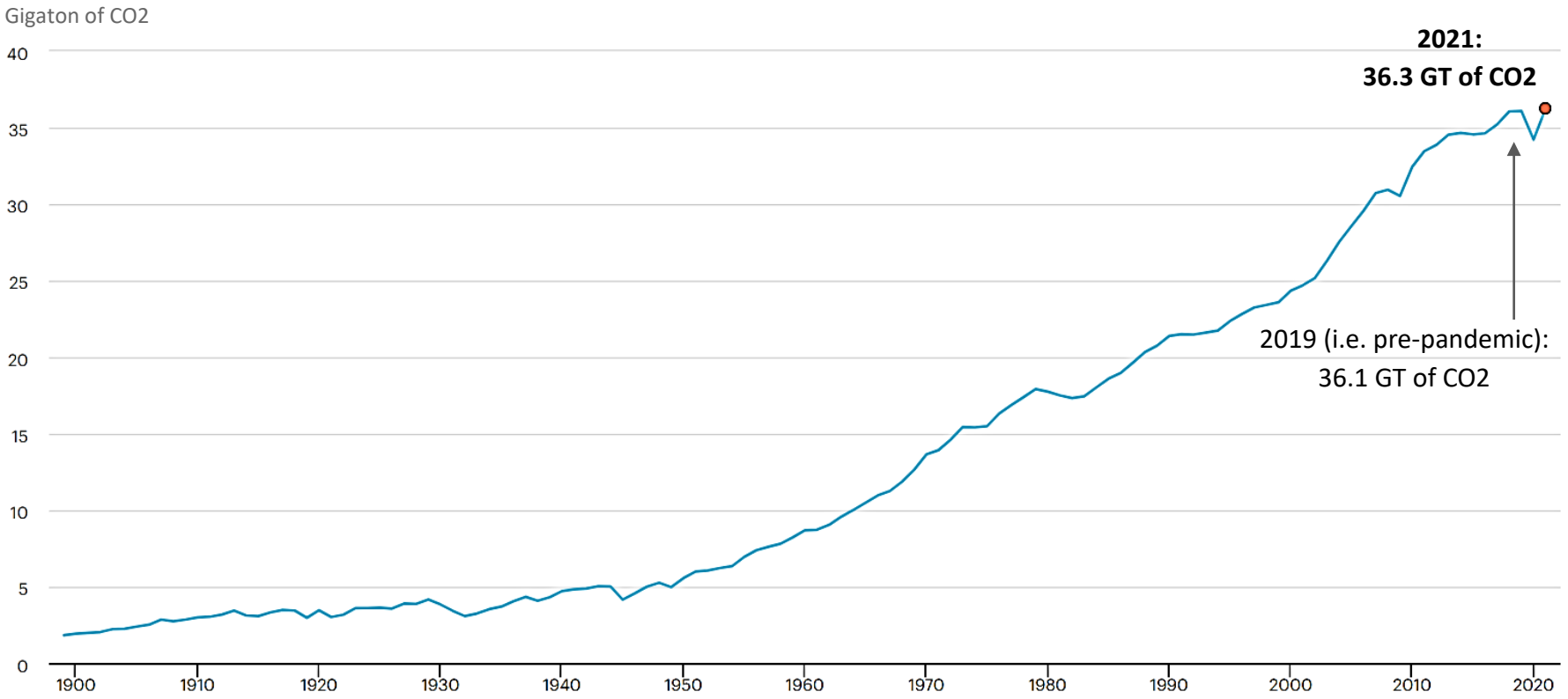
Turbine Replacement by large MW electric motor

Top Industrial Efficiency

Climate change – CO2 emissions

CO2 emissions rebounded to record levels in 2021 despite expectations of emissions peak – jump above pre-pandemic levels driven primarily by coal use in China

CO2 emissions from energy and industrial processes (1900-2021)



Comments

The economic rebound seen in 2021 lead to **global CO2 emissions** more than reversing the decline seen in 2020 as the pandemic hit the globe

The emissions growth vs. pre pandemic was primarily driven by **China**, with **coal-fired power plants** put into use to meet the over 10% growth in electricity demand, a record growth rate

In the **US** and **EU**, emissions rebounded in 2021 but remained below pre-pandemic levels, potentially signaling a continued emission decline trajectory

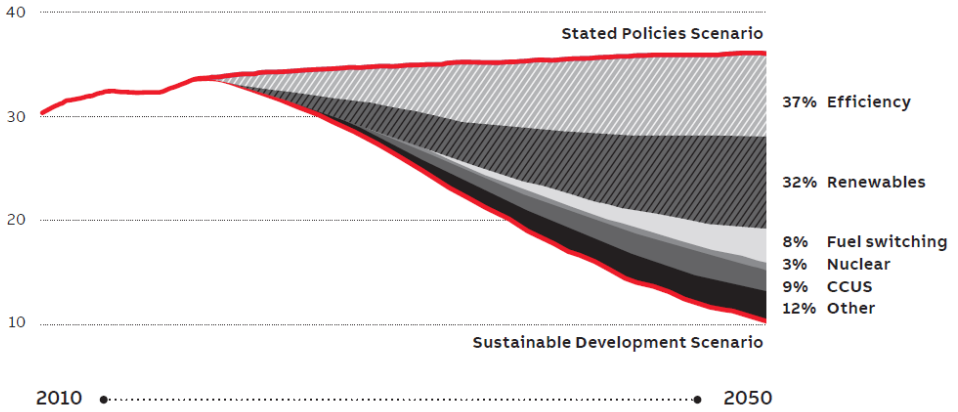
 Source: IEA

Fact based steps to sustainability

Current situation

Sustainability though energy efficiency

The percentage of greenhouse gas reductions achievable by sector in meeting the Paris Agreement goals. Source: IEA Energy Outlook 2019[3]

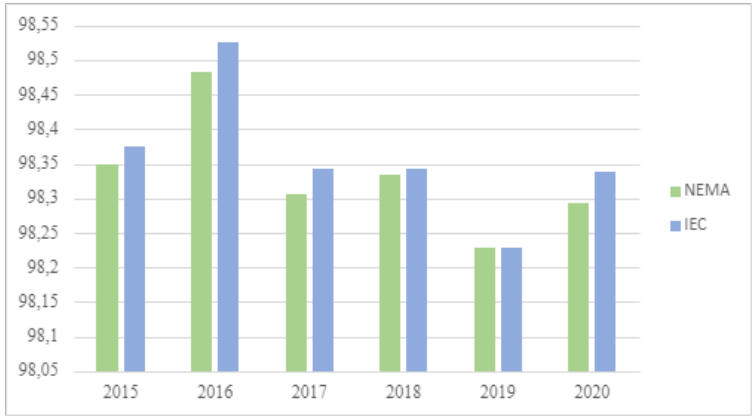


Increaseing the efficiency is considered to be the largerst contributor to reaching the Paris agreement

Minimum efficiency performance standards have been introduced for small motors already in 2011 and it has helped increase focus on efficiency

There will be a new standard released for MV motors 2022, it only goes up to 2MW and the highest efficiency requirement in that standard (IE4) is below 97%. The reason is that larger motors are considered to already be efficient.

We have solutions with higher efficiency than what the market buy*



Average efficiency % of all units delivered

For large motors and generators produced in Vasteras ABB has tracked the efficiency of all delivered units under a long time.

We see that our products are well above the standards, and we often focus on optimizing on cost instead of efficiency

If the most efficient product had been bough instead it would contribute to a 0,8Mton CO2 reduction per year or 6% of Sweden's total CO2 emissions related to electricity production

* Data from the large motor and generator factory in Vasteras (one single site) just to highlight actual potential

Top industrial efficiency (TIE) option

Fast way to create a market pull for higher efficiency enabling a more sustainable world

Problem

The market does not buy the most efficient solution

- Higher CO2 emissions
- Higher life cycle cost over time

It is complex to specify efficiency if there is no standard

The IE standard used for electric motors is only available for small motors and takes time to expand both in size and scope

There is limited structured, independent and transparent sharing of company contribution (CO2 saving).

Greenwashing or ambitions targets without actions is not improving environment, it needs to become tangible

Solution

Participating companies, as the experts on our respective products, offer an option where we highlight the most efficient alternative in our quotations

We legally commit to do our best and remove all barriers to select that option

We go from compliance to commitment to a more sustainable future

"The supplier guarantee to supply the most efficient product/system that we currently can offer without affecting the reliability or increase the complexity of the product/system.

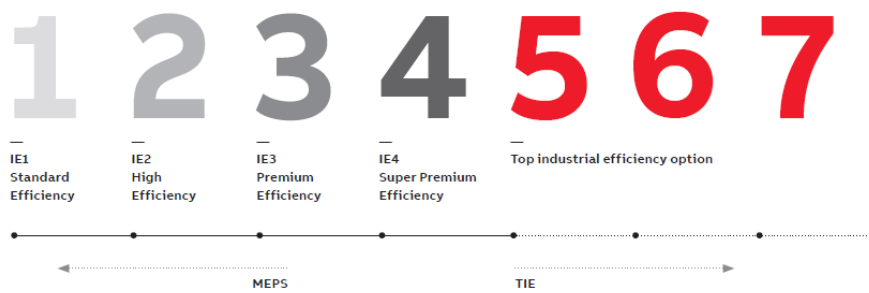
Upon the Purchaser's written request, the Supplier must be able to reasonably substantiate that the design, material selection and manufacturing comply with the above guarantee. The Purchaser, or a third party appointed by the Purchaser, may, at its cost, review such substantiation. Should the Supplier fail to substantiate compliance with the TIE Option, the corresponding energy and CO2 costs for the Customer during the first 100 000 hours of operation will be paid back to the Purchaser, however in no case exceeding the additional price paid by the Purchaser for the TIE Option. The compensation set out in this section is the Purchaser's sole and exclusive remedy available for the TIE Option.

By using the TIE concept the parties agree to submit and share data regarding the estimated CO2 savings achieved or if a supplier fails to www.topindustrialefficiency.eu

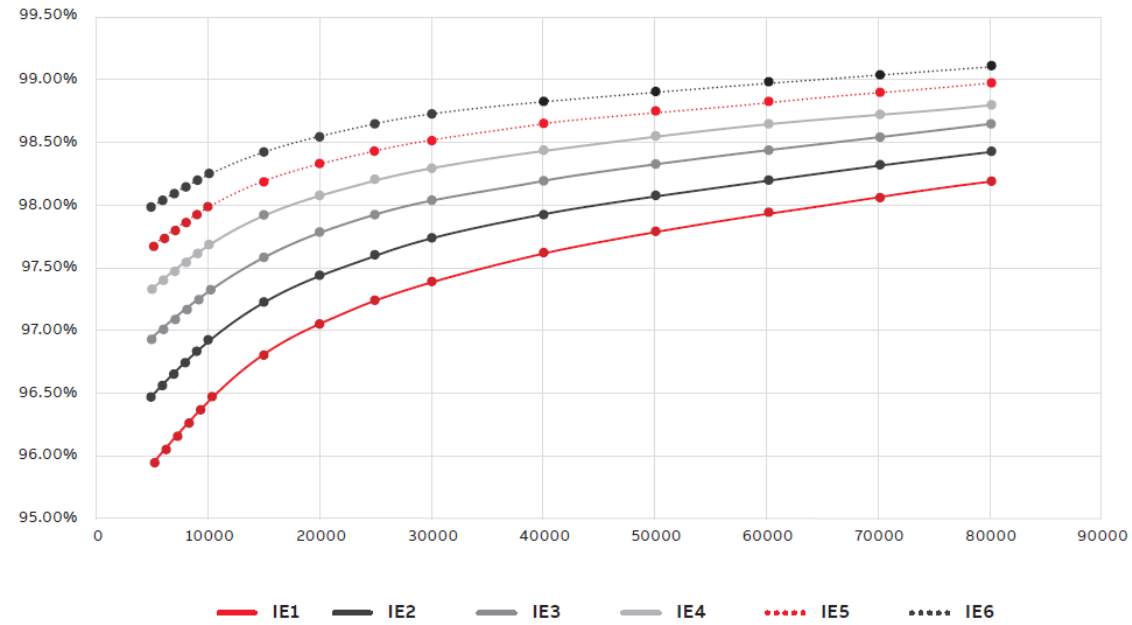
Top industrial efficiency (TIE) option

Illustration of top industrial efficiency option in comparison with current IE levels

Relative Illustration of top industrial efficiency option in comparison with current IE levels.



Efficiency vs Output (kW) extrapolation for efficiency classes IE1 to IE6.



Key benefits of the TIE option

- Secure the future by using the most energy-efficient technology
- A concrete way to live up to company values
- Lower operational and life cycle costs and increased bottom line
- A legally binding contract

All barriers removed:

- Same performance, no added deviations to specs
- No extra complexity, same ease of use
- No compromise on reliability, same proven technology
- A practical measure open to all

High efficiency for a sustainable future

Why 0.7% matters

WR 99.05%

Efficiency comparison and affect

Compared motors efficiency (15MW)

Synchronous motor: 98.5%

Induction motor: 97.8%

Input data (us)

$/kWh = 0.108

CO_2 = 481g/kWh

Time-frame = 20 years

Motor in operation= 95%

Purchasing cost

Synchronous motor- induction motor →: $240k

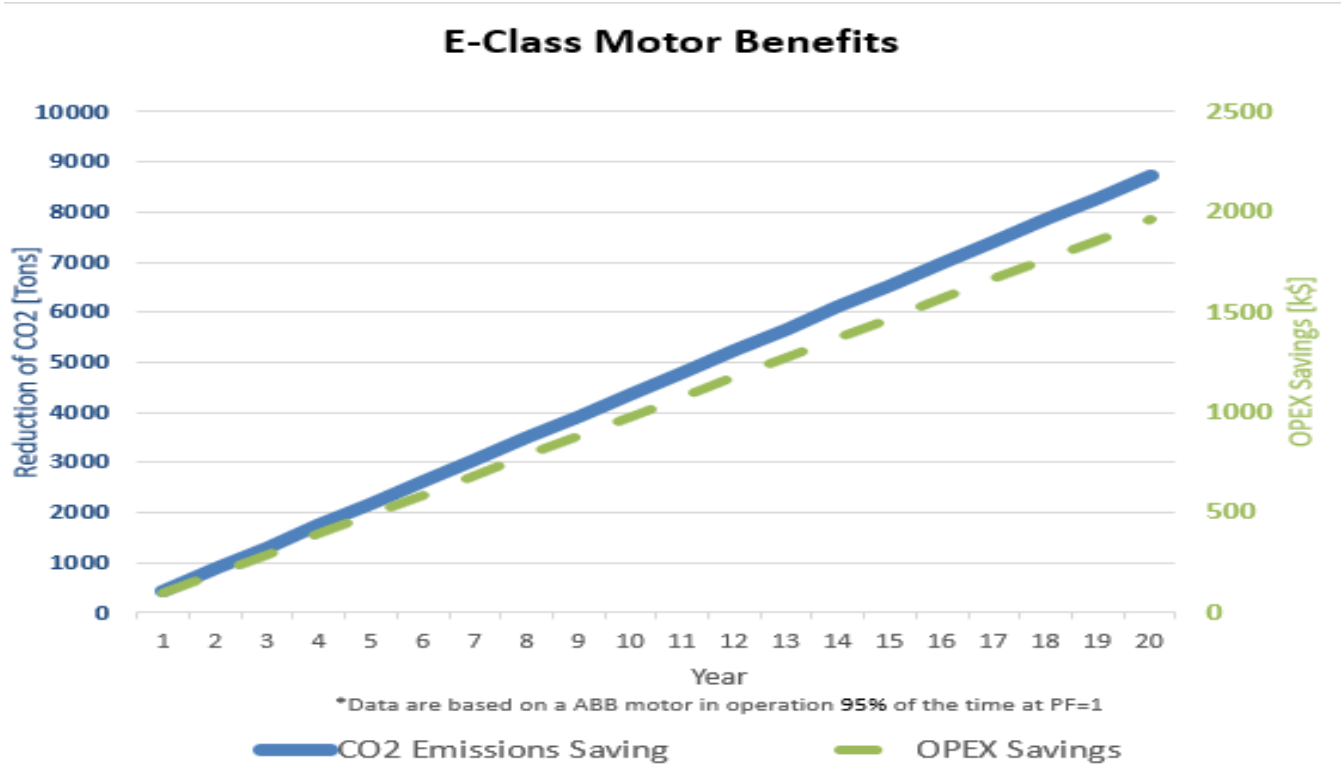
Summary:

CAPEX investment paid off in 2,5years *)

Time frame savings→ $2000k *)

Time frame CO2 reductions→ 9000 Ton

***) excluding CO2 emission fees**



Long term relationship with our customers – Cost of ownership

Think long term – more than energy efficiency

- How much does it cost to own a product over its expected lifetime?
  - A motor, irrespective of its rating, will consume its purchase price in energy costs during its first month of continuous operation. Cost of the motor itself is normally <<0.5% of the motor total cost over its lifetime when coming into MW ranges
  - Downtime at a major plant might cost k$...m$ per day
- Reliable, high efficiency motors deliver the lowest life cycle costs
- Advanced diagnosis tools enhance equipment reliability and minimize unplanned system downtime

A tangible step to a sustainable future:

- Secure your future by using the most energy-efficient technology
- A concrete way to live up to your values as a company
- Lower operational and life cycle costs, increases your bottom line
- More than words, a legally binding contract

All barriers removed:

- Same performance, no added deviations to your specs
- No extra complexity, same ease of use
- No compromise on reliability, same proven technology

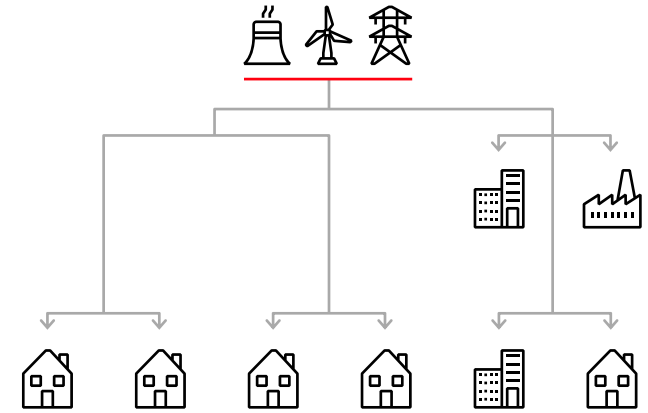
Synchronous Condensers

Synchronous condensers – Why

Different implications

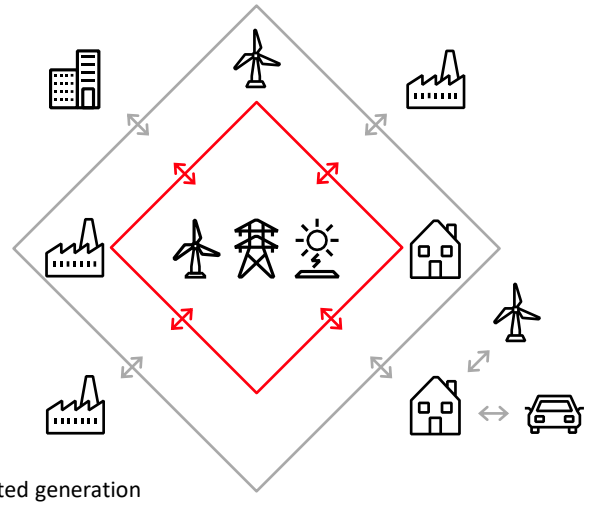
- Generation
- Transmission
- Distribution
- Industrial C.
- Residential C.

Traditional grid



- Centralized generation
- Generation with spinning mass
- Few power electronics based generators
- Strong grid
- One way communication
- Few sensors
- Manual monitoring and manual restoration

Future grid

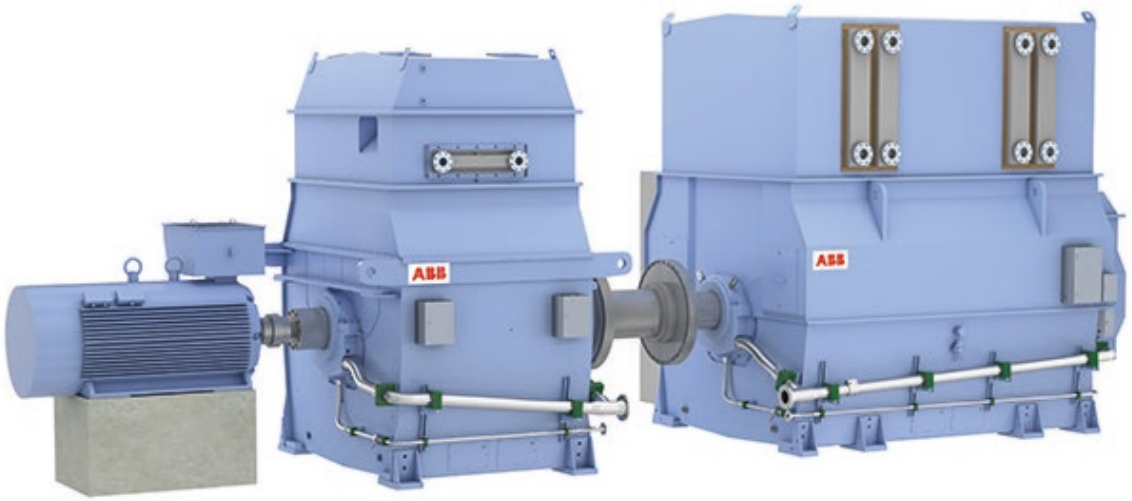


- Distributed generation
- Less generation with spinning mass
- Inreased amount of power electronics based generators
- Weaker grid
- Two way communication
- Smart sensors
- Self monitoring and self healing

Strong → Weak → Very weak

ABB Synchronous Condensers for power grid stability

What is a Synchronous Condenser?



Definition:

Synchronous condenser is a synchronous machine operating without a prime mover. Generation/absorption of reactive power is achieved by regulating the excitation current.

Synchronous condensers with flywheels provide significantly increased instantaneous inertia, short circuit current capacity and dynamic reactive power to support electric grid voltage and frequency stability.

Key benefits:

- Short-circuit power for increased transmission capacity and excellent fault ride-through capability
- Significant overload capability to support network during prolonged voltage sags
- High and instantaneous inertia, which ensure stable network frequency.
- Ability to supply and absorb reactive power

Synchronous condenser engineered package – What

Installation from site Musselroe, Tasmania with two unit's synchronous condenser 14000 kVAr and pony motor

Synchronous condenser unit

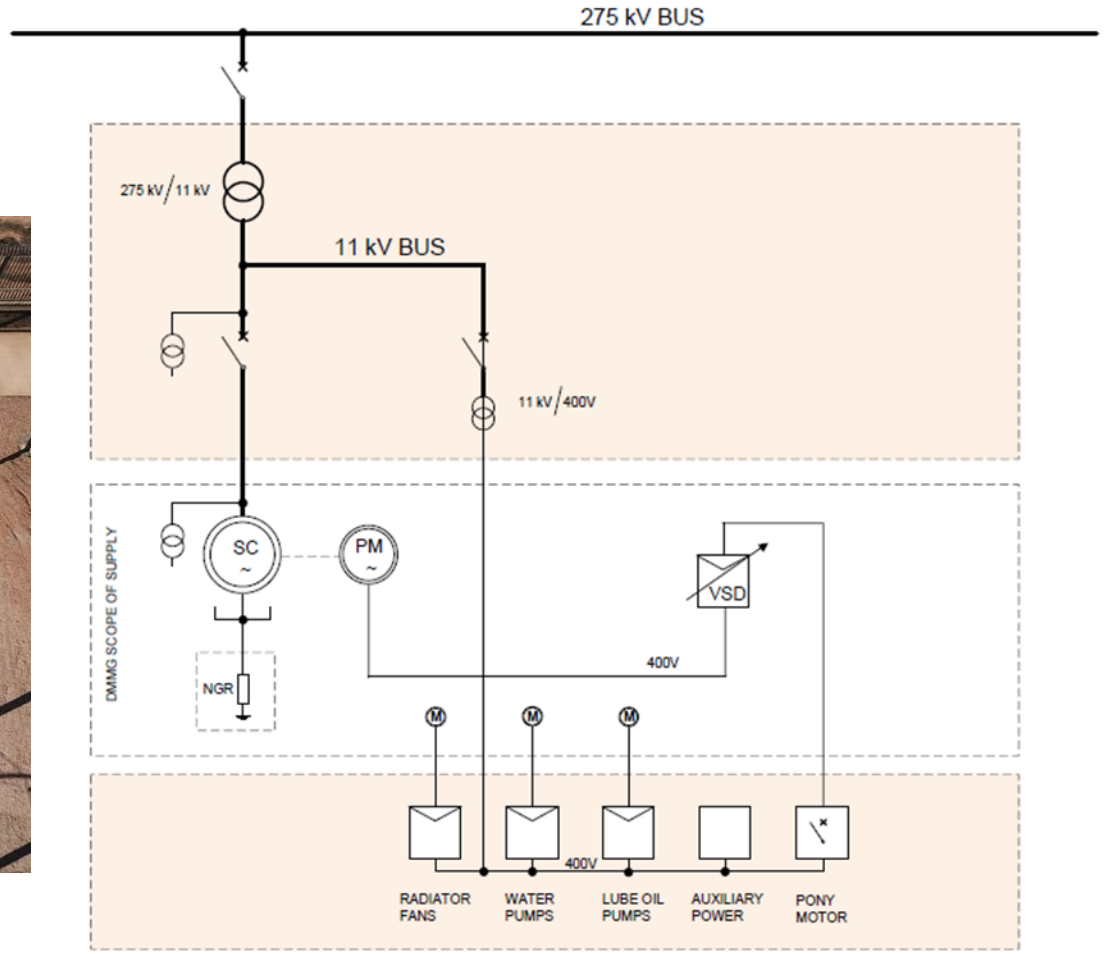
Fin fan cooler

Main terminal box

Pony motor Lube oil tank unit

Synchronous condenser engineered package – Finley Solar Park Australia

AMS 1400, 60 MVAr, 11 kV, IP 55, 50kA 3sec



Challenges in the network

Solutions/ Mitigations

Grid	Problems	Solution with ABB SC[1] at the connection point
Weak network (Ik)	Short circuit capacity is reduced due to retirement of large fossil fuel power plants and increased number of new industries	Add x-units of new SCs to improve the total network and get partly redundancy for service shut down
Unstable network (Hz)	Frequency fluctuating due to increased new load types	With high inertia it can stabilise the frequency
Long distribution lines (V)	Voltage sags due to many consumers over long distances	Stabilise the voltage by boosting output for several 100 ms
Temporary/ periodically peak loads	Can be from process industries or unusual circumstances	SCs have high overload capability for 15-30 min
Temporary disturbances	Can be from lightning strikes or equipment failure	With high inertia SCs have good performance to ride through a fault

[1] ABB can optimize the machine design based on project requirements

Synchronous condensers

Summary

Synchronous condenser features

- Strengthens the network by adding short circuit capacity
- Rotating inertia provides stability to the network
- Dynamic MVAr´s support voltage control
- High thermal over-load capacity
- Very good ride-through capability

Market view

- Reborn interest due to more renewables
  - Market increase
- Network studies can be required
- Sometimes turn-key solution requested


ABB