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29th March 2019, Hacettepe University

Chapter:05

Introduction to Electricity and Power Generation Basics

Siemens Course: Engineering in Energy Market, Süha IŞIKLI

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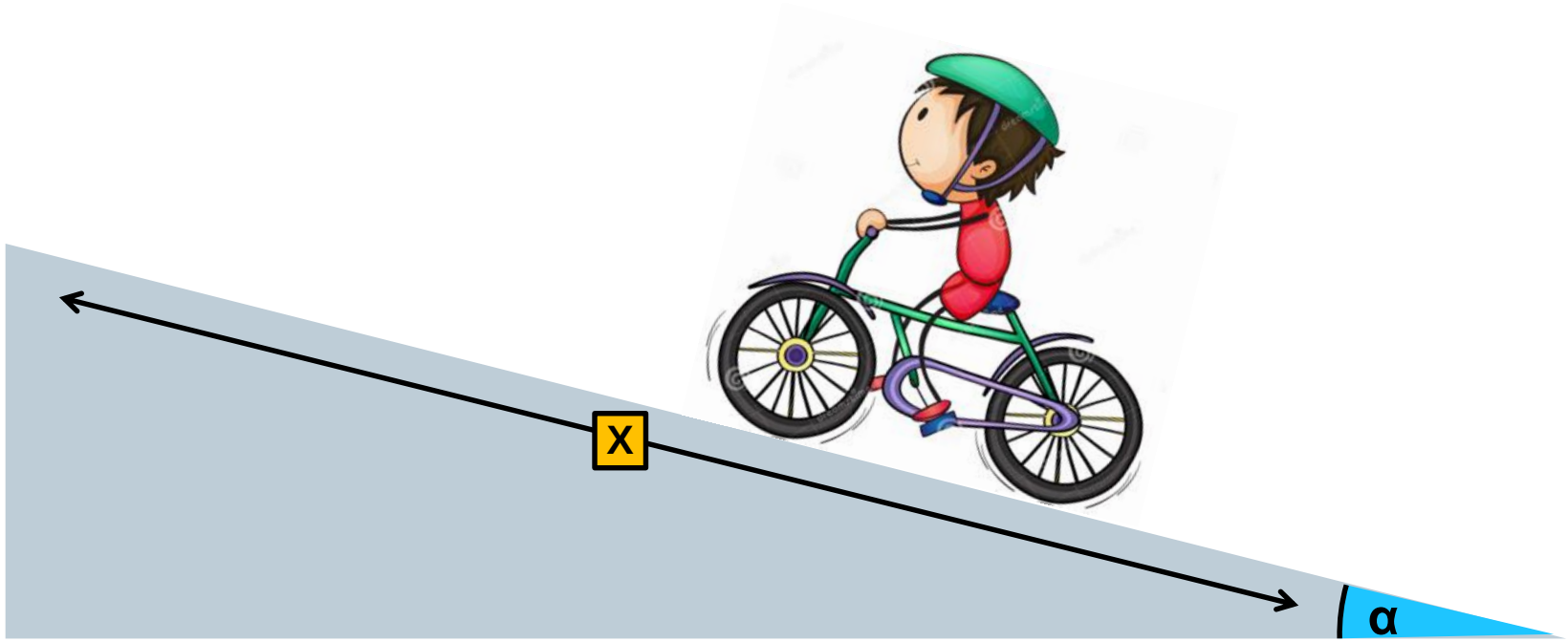
Section:01

Main Concepts in Power Engineering

ENERGY

POWER


X
α

ENERGY = POWER x TIME

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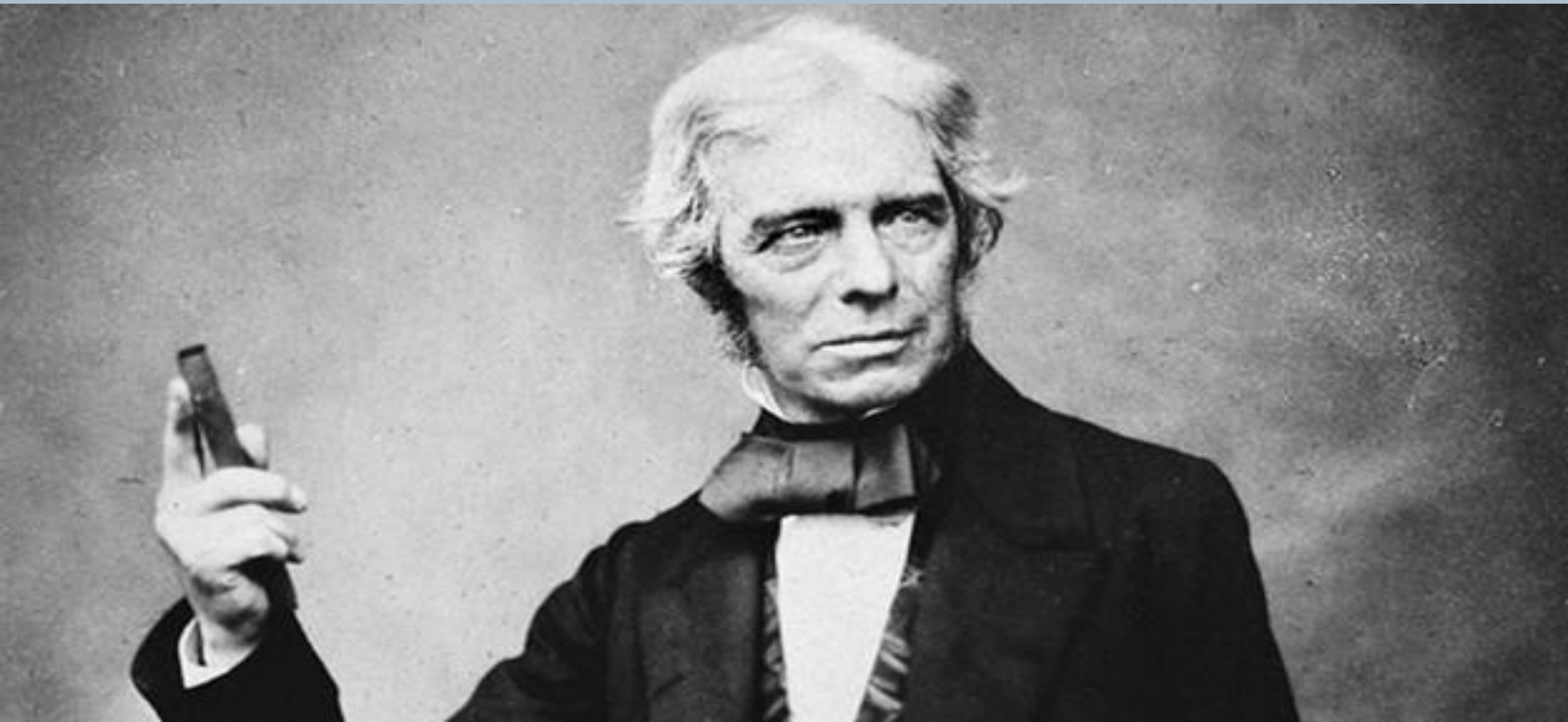
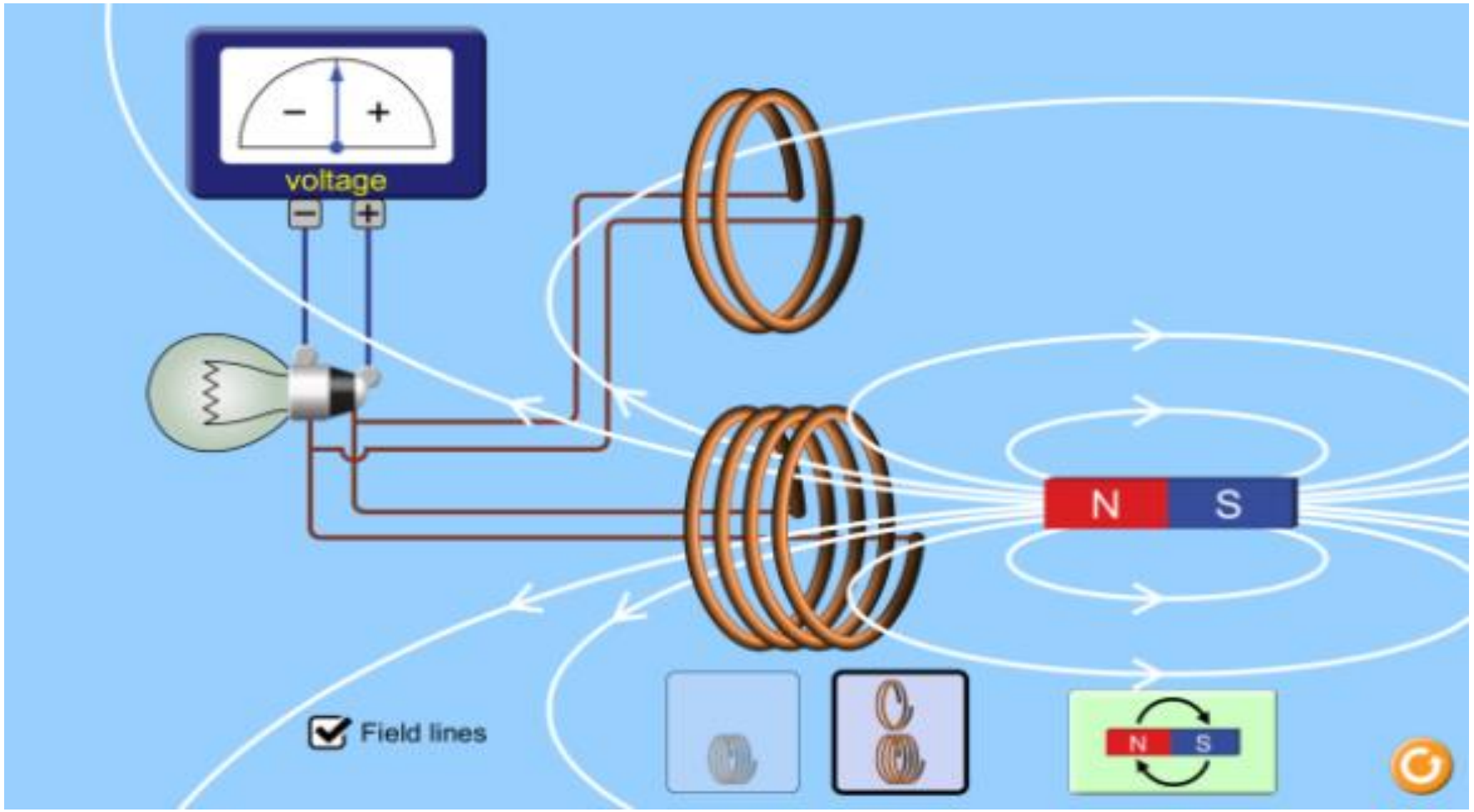
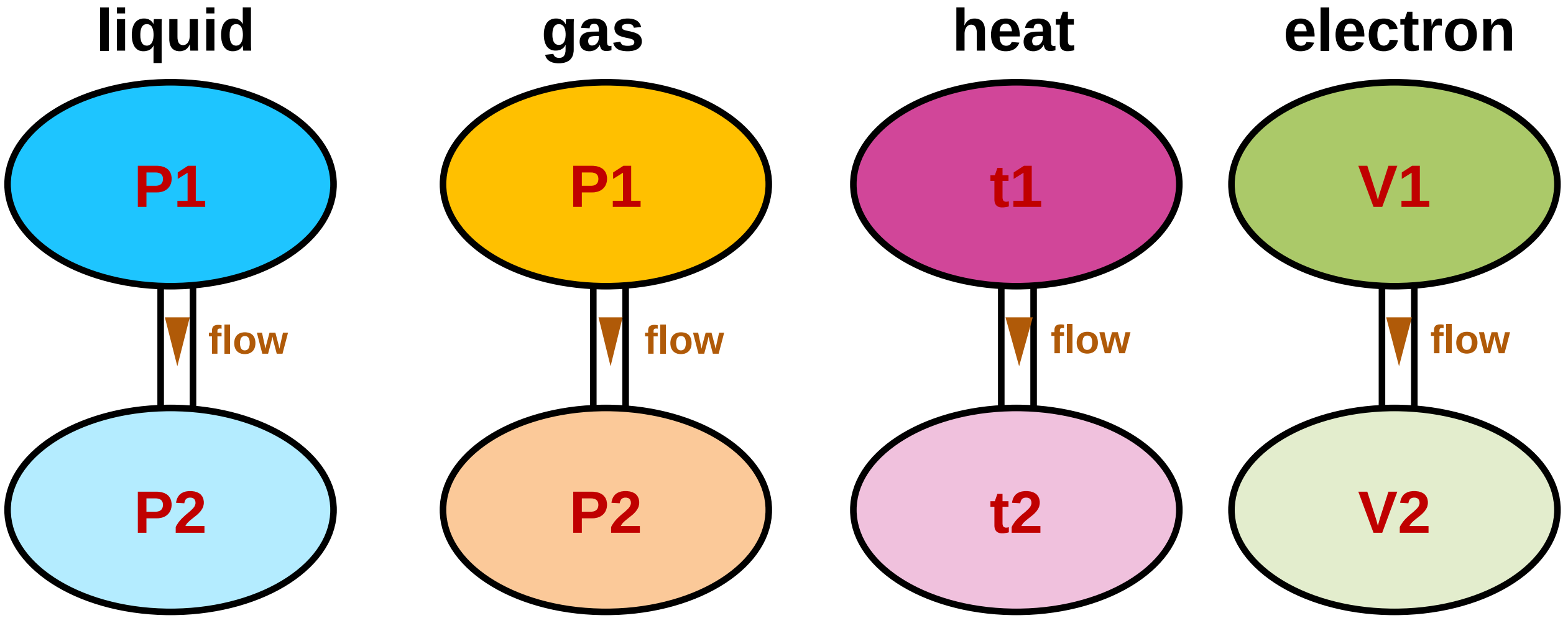
Michael Faraday



Faraday's Law



Power = V x I


liquid
P1
flow
P2
gas
P1
flow
P2
heat
t1
flow
t2
electron
V1
flow
V2

Power = V x I

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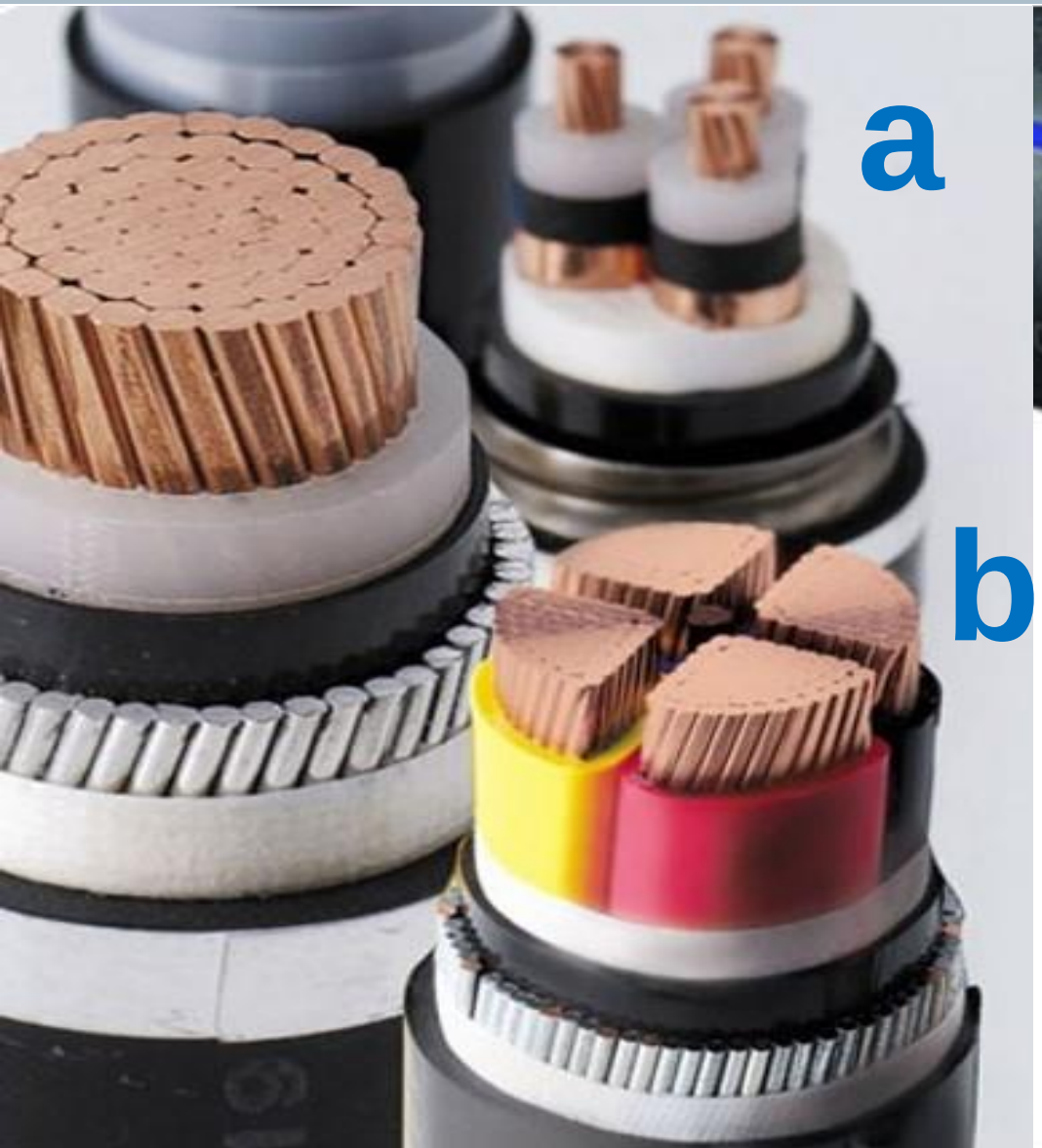
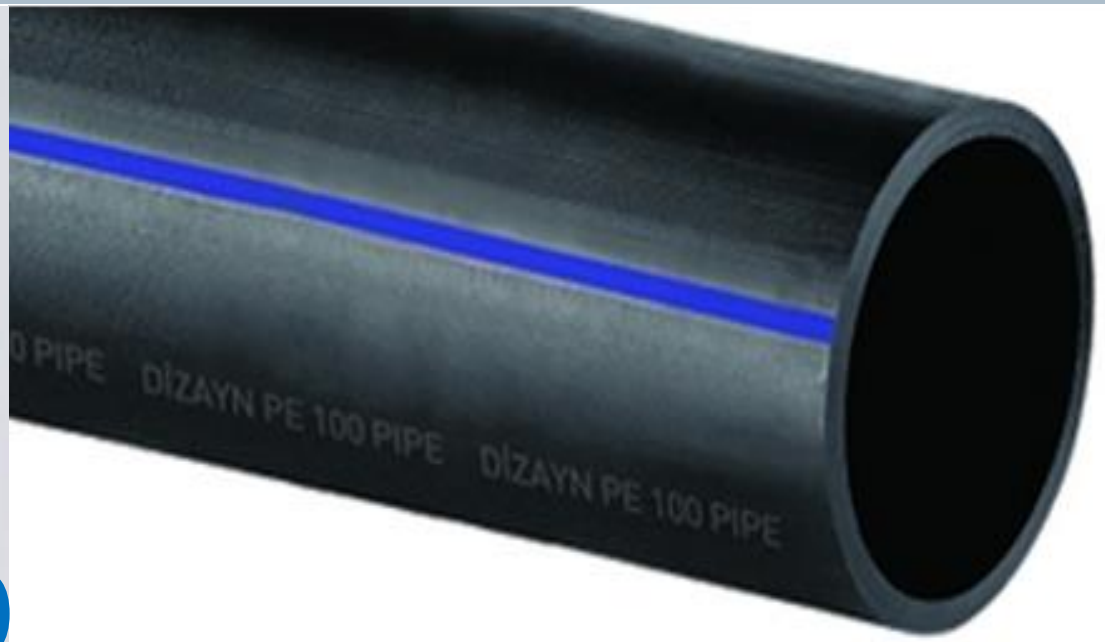


a

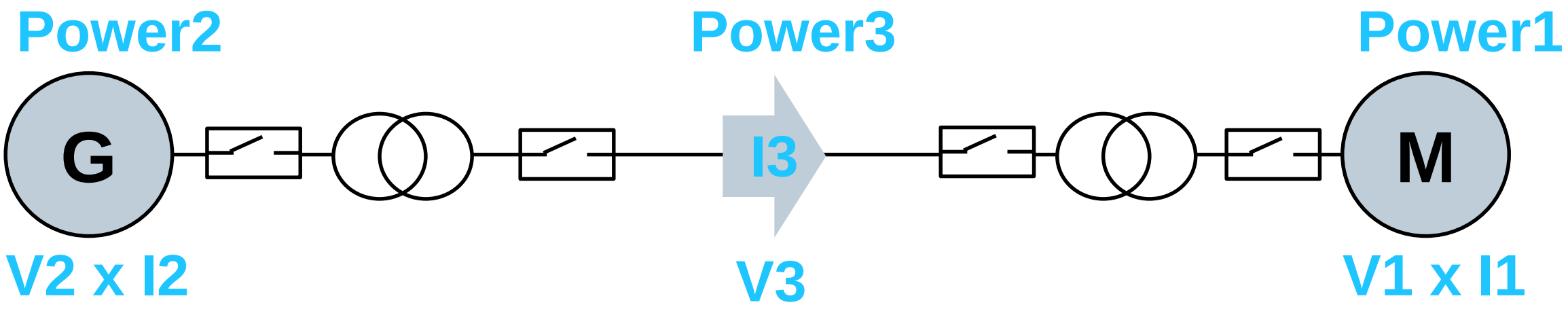
b



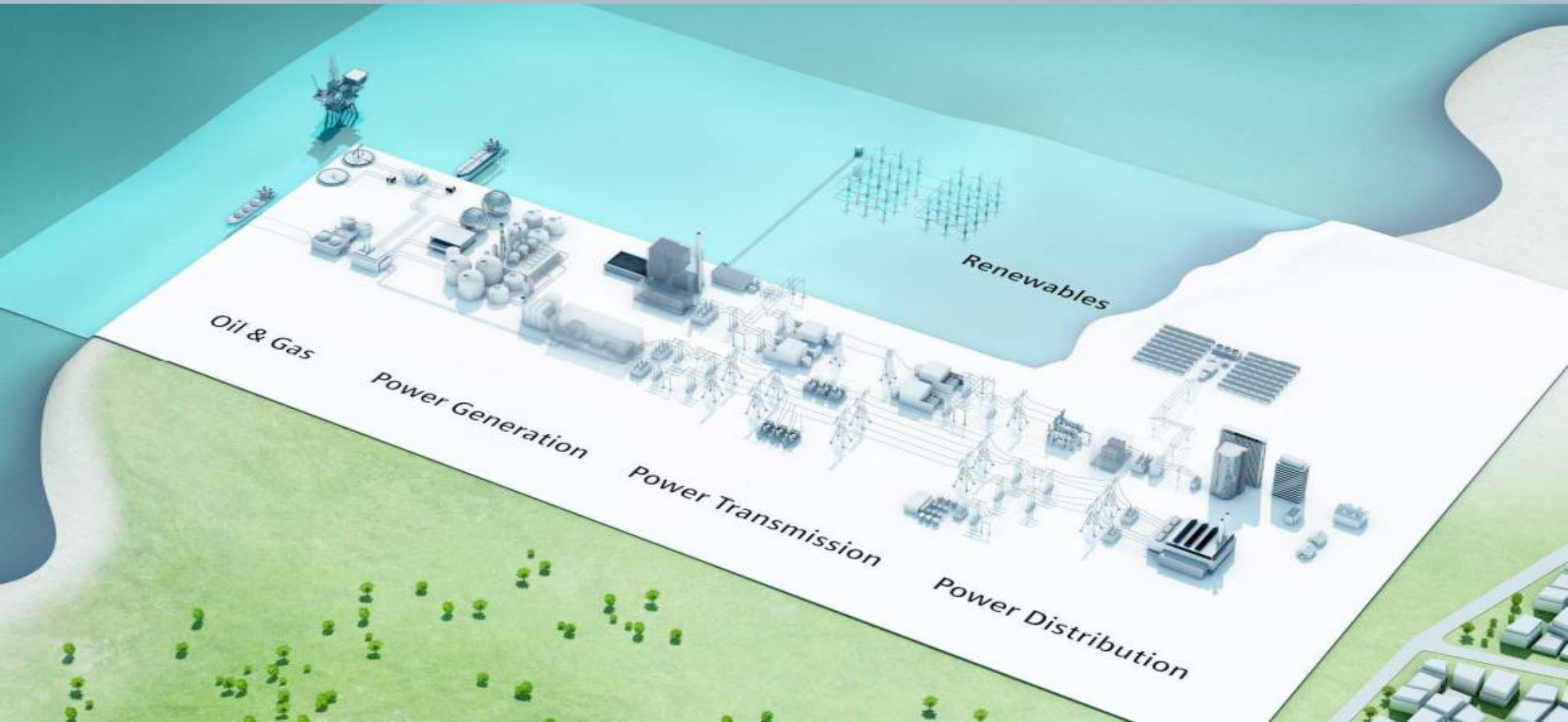
d

c

Power = V x I



Power Map

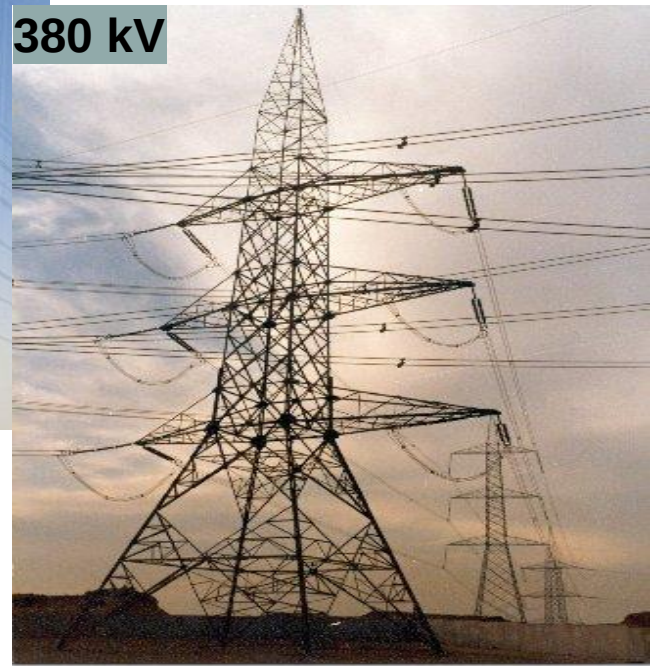

Renewables
Oil & Gas
Power Generation
Power Transmission
Power Distribution

Voltage Levels


House overhead line


36 kV


154 kV


380 kV

Why do we have different voltage levels?

Transformator

Busbar = connection that carries very large currents

StepUp SubStation

StepUp SubStation

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Section:02

Power Outlook of Turkey

Installed Power Capacity 88,4 GW*

*By the end of year 2018 .

Generated Energy

300.000 GWh*

*During the whole year of 2018 .

Ave. Duration of Generation ~3400h

Percentage of Use

%39*

*Can also be named as Efficiency.

PopQuiz #01

32MW Wind Park

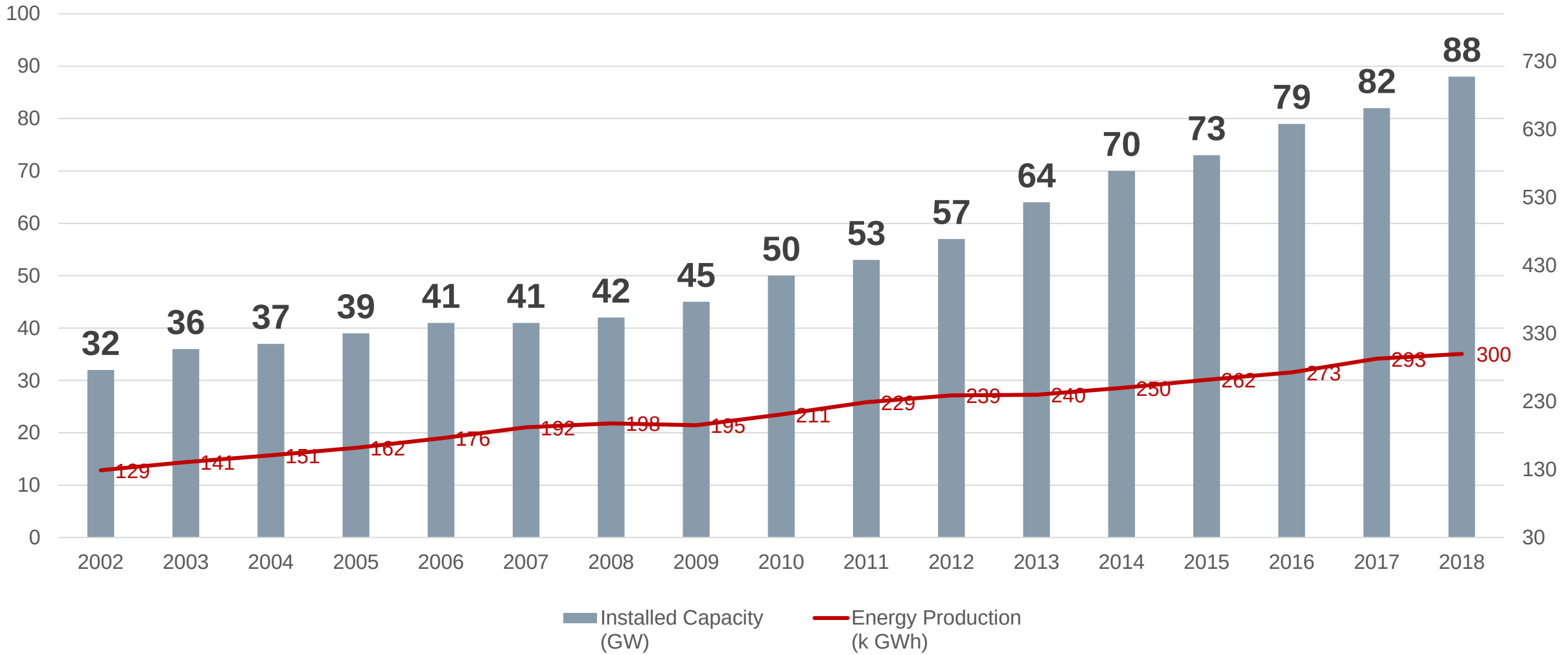
- If we assume the total efficiency as %35
- What is the total energy that can be generated in one year?

- How many house can survive with this production?
- If we assume the total consumption of an ordinary household as 165kWh per month.

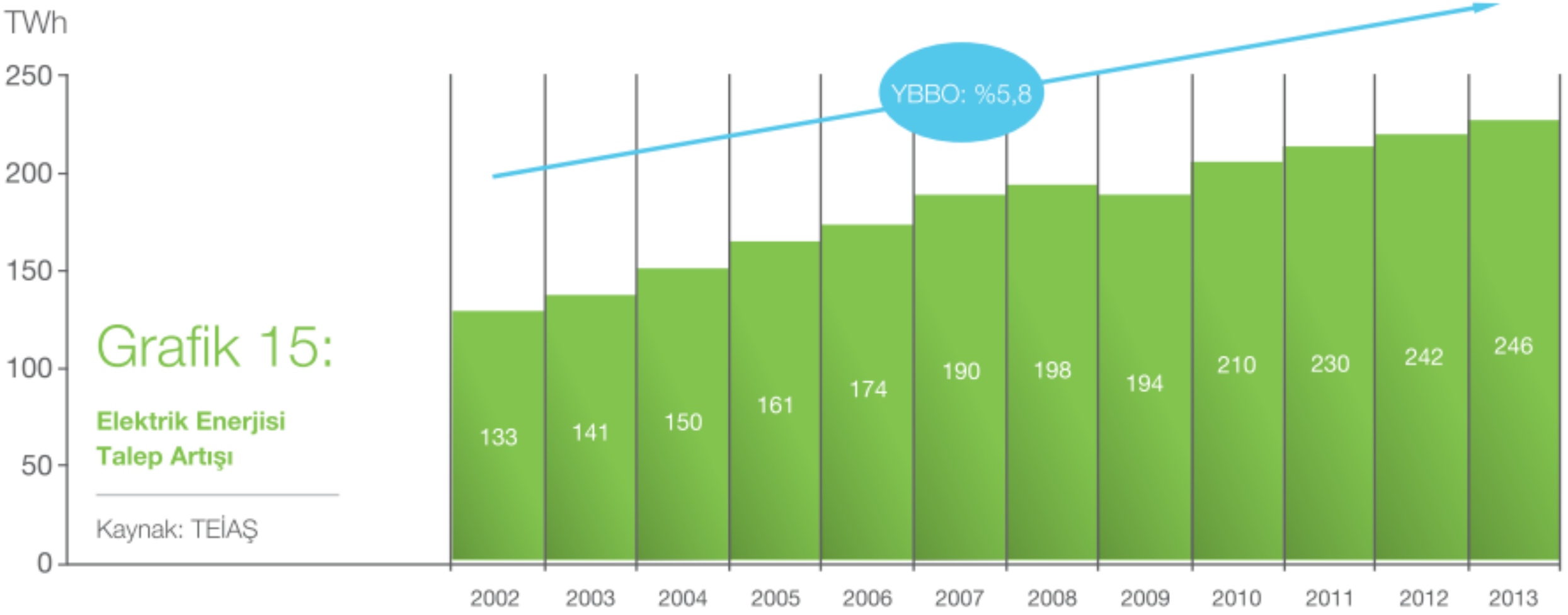
32MW Wind Park

- If we assume the total efficiency as %35
- What is the total energy that can be generated in one year?
- 100M kWh(~)
- How many house can survive with this production?
- If we assume the total consumption of an ordinary household as 165kWh per month.
- 2K kWh (for one house per year)
- 50K household can survive by the generation of this wind park

Turkey Installed Capacity Development



Turkey Energy Demand Development



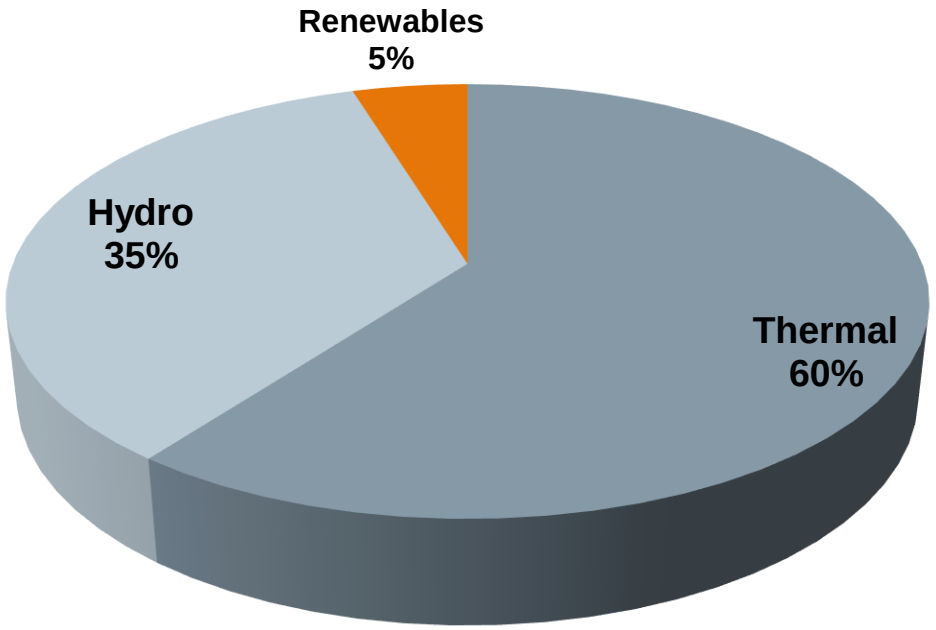
Grafik 15:

Elektrik Enerjisi Talep Artışı

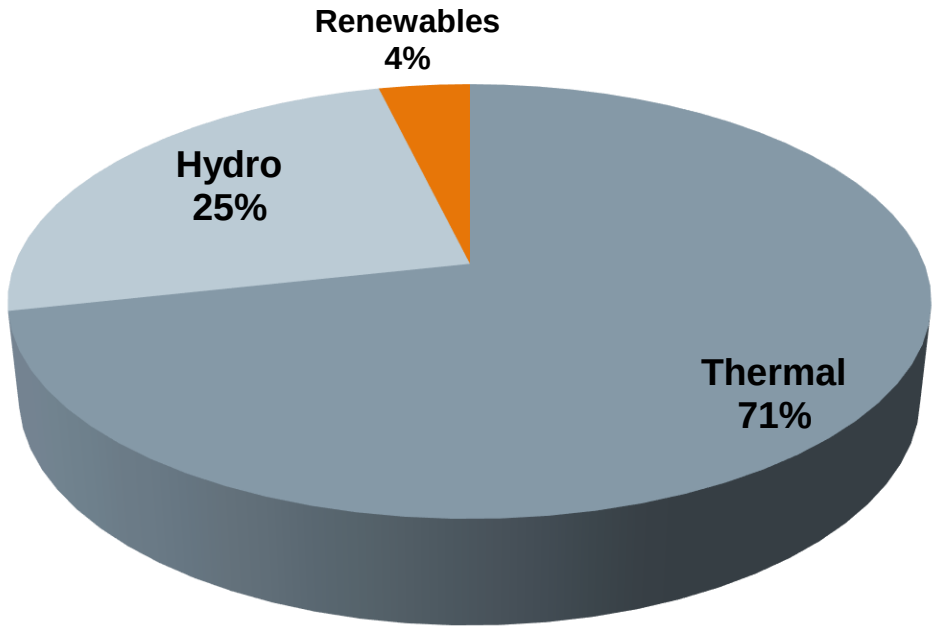
Kaynak: TEİAŞ

Turkey Power Mix_2013

Installed Capacity

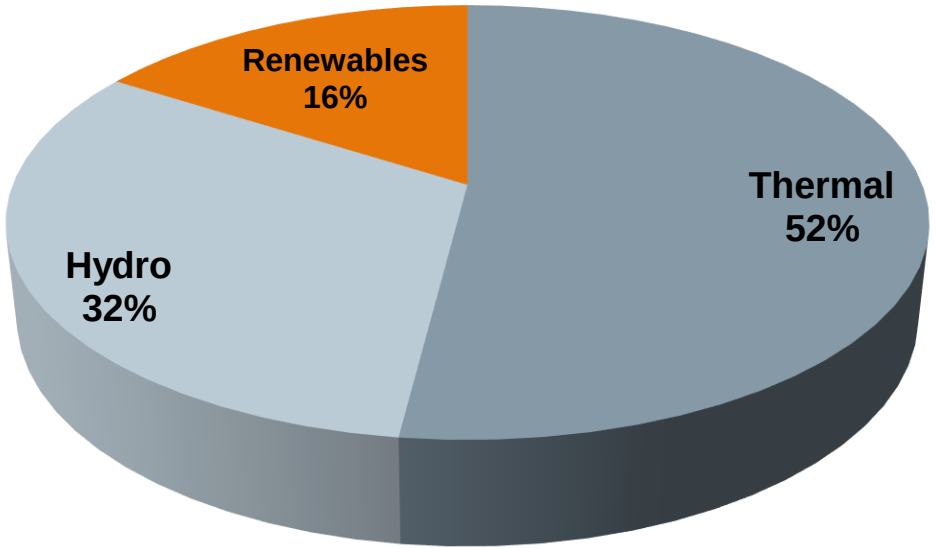


Energy Generation

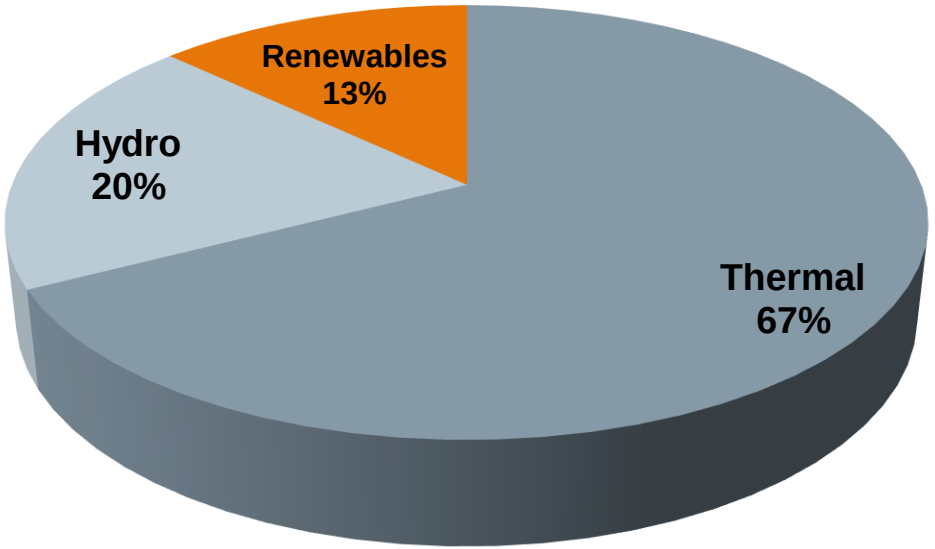


Turkey Power Mix_2018

Installed Capacity



Energy Generation

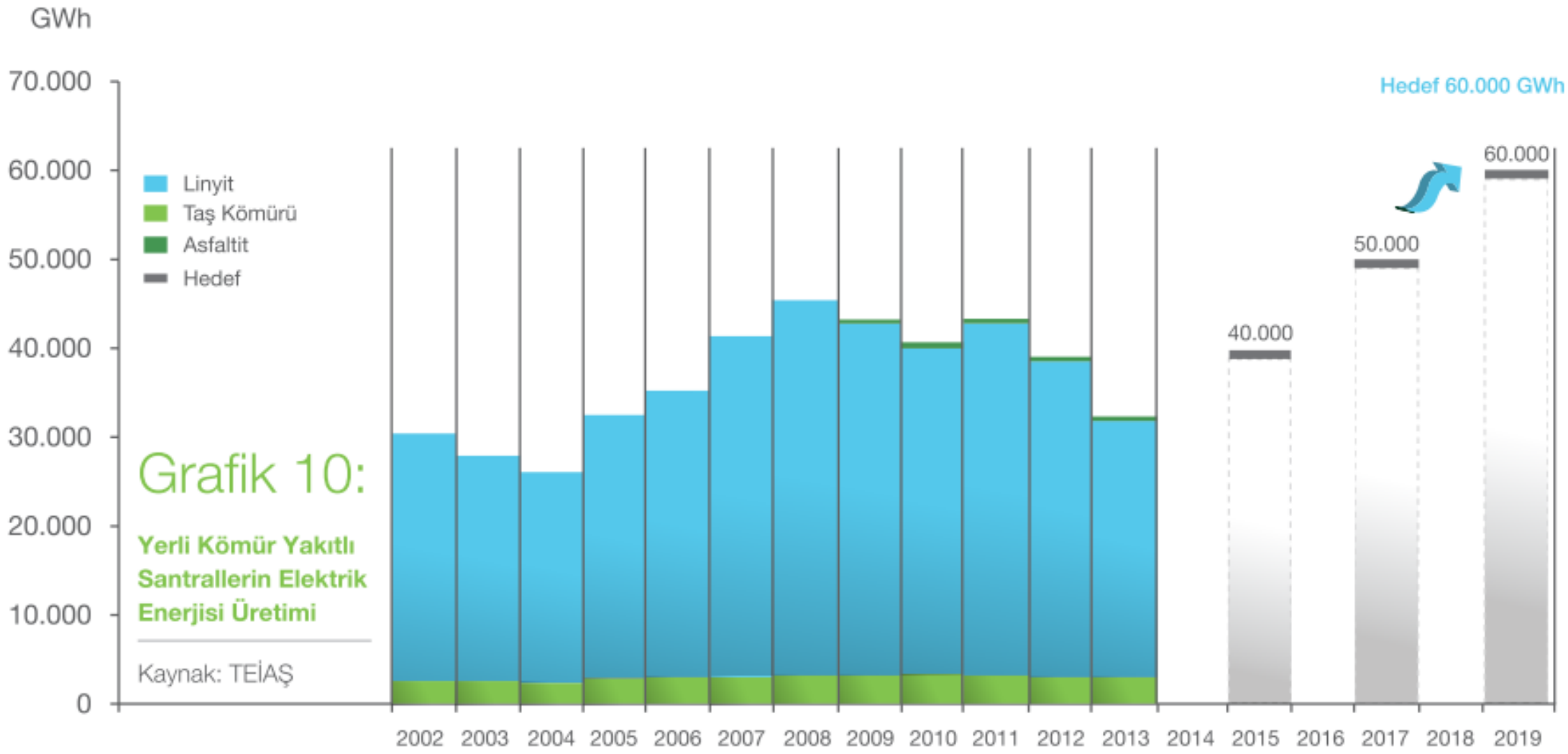


Energy Strategies

Kalkınma Bakanlığı Öncelikli Dönüşüm Programı (2014-2018)	2014	2018
Yerli kaynaklı enerjinin üretimde payı *(%)*	27	35
Yerli Kömür kaynaklarının enerji üretimi *(milyar kWh)*	32	57

- Yerli kömür kaynaklı santraller; sahaların özel sektöre devri, rehabilitasyon
- *Su kaynakları; kamu HES'lerinin rehabilitasyonu*
- *Yenilenebilir; jeotermal aramalar, yatırım gerçekleşme izleme sistemi*
- *Kojenerasyon, Mikrojenerasyon; Atık ısı*
- *Hidro; ilave 10GW su kapasitesi*
- *Doğalgaz depolama*
- *Sanayide enerji verimliliği*

Energy Strategies



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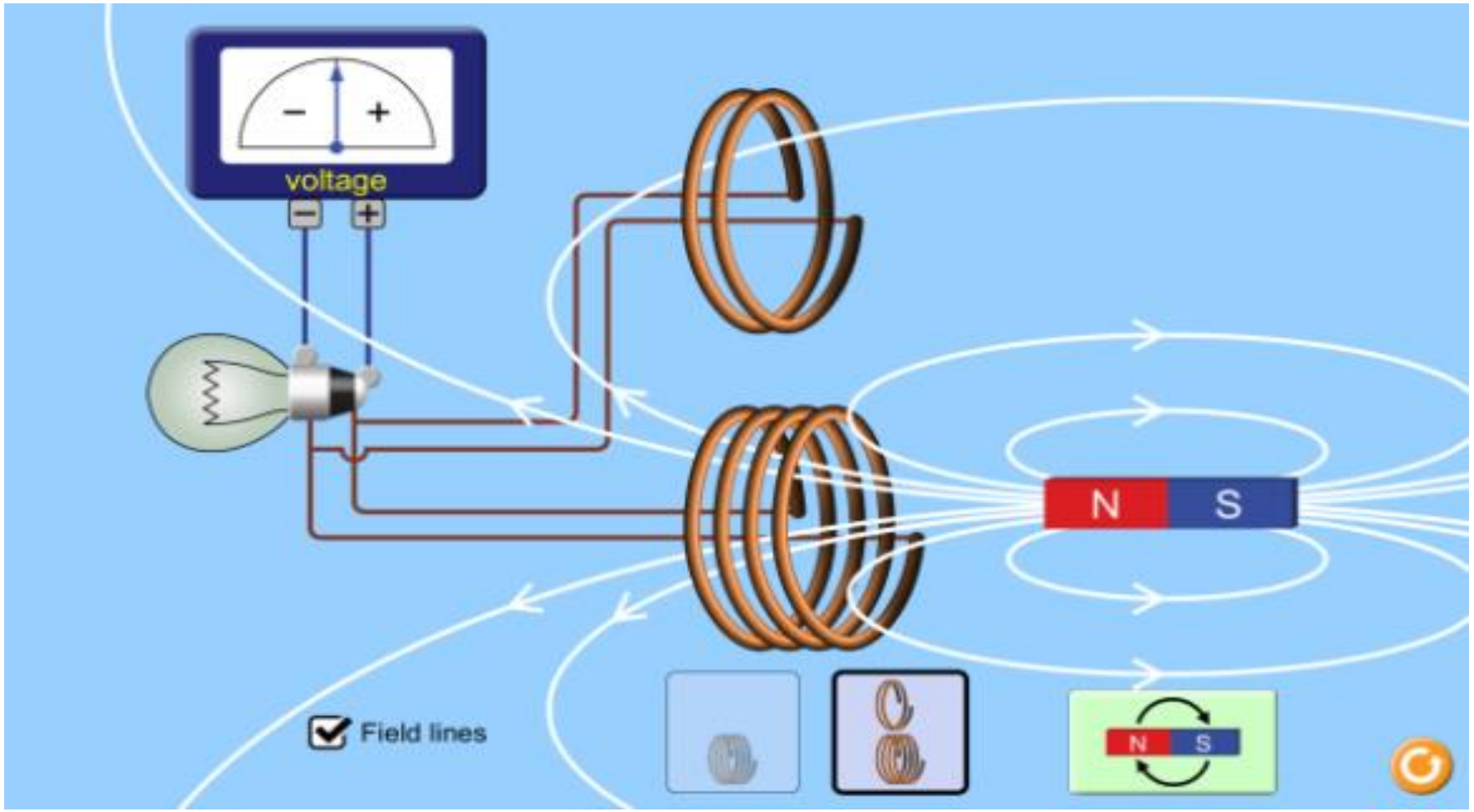
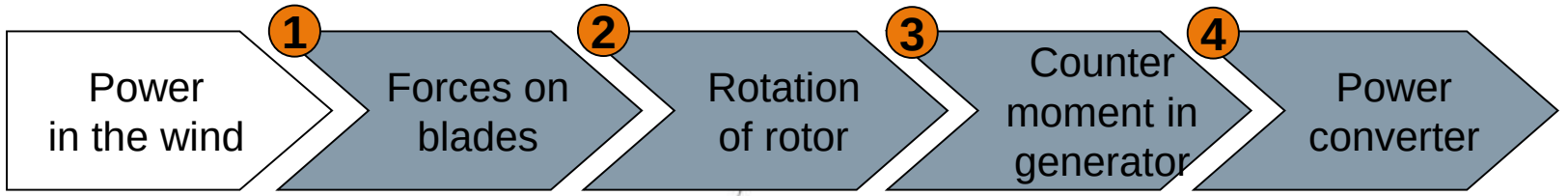
Section:03

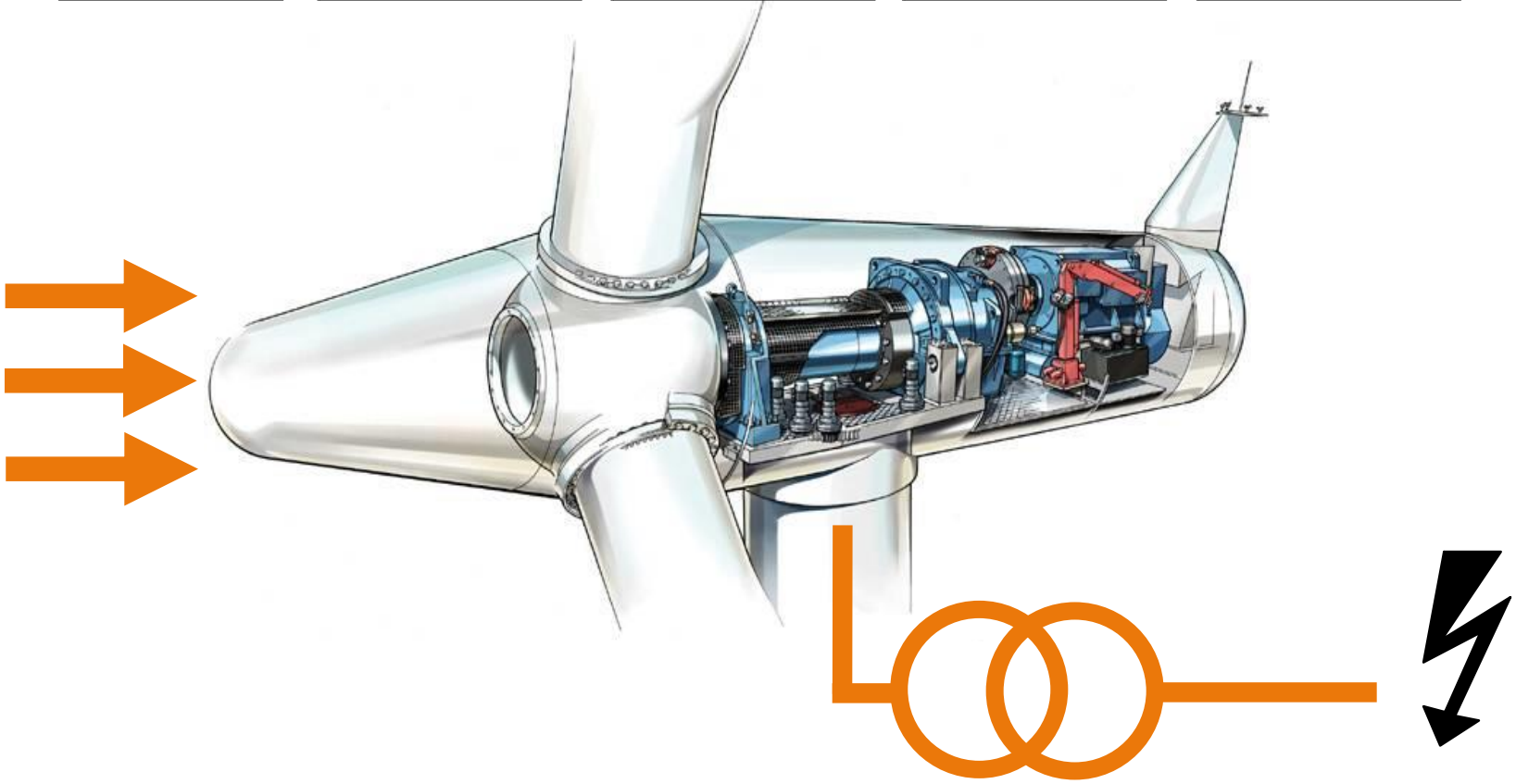
Renewable Power Generation and Wind Turbines

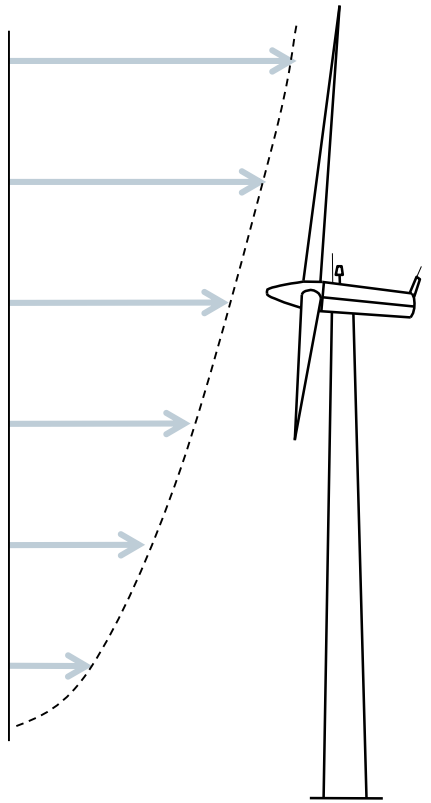
Faraday' Law



Wind Turbine Basics

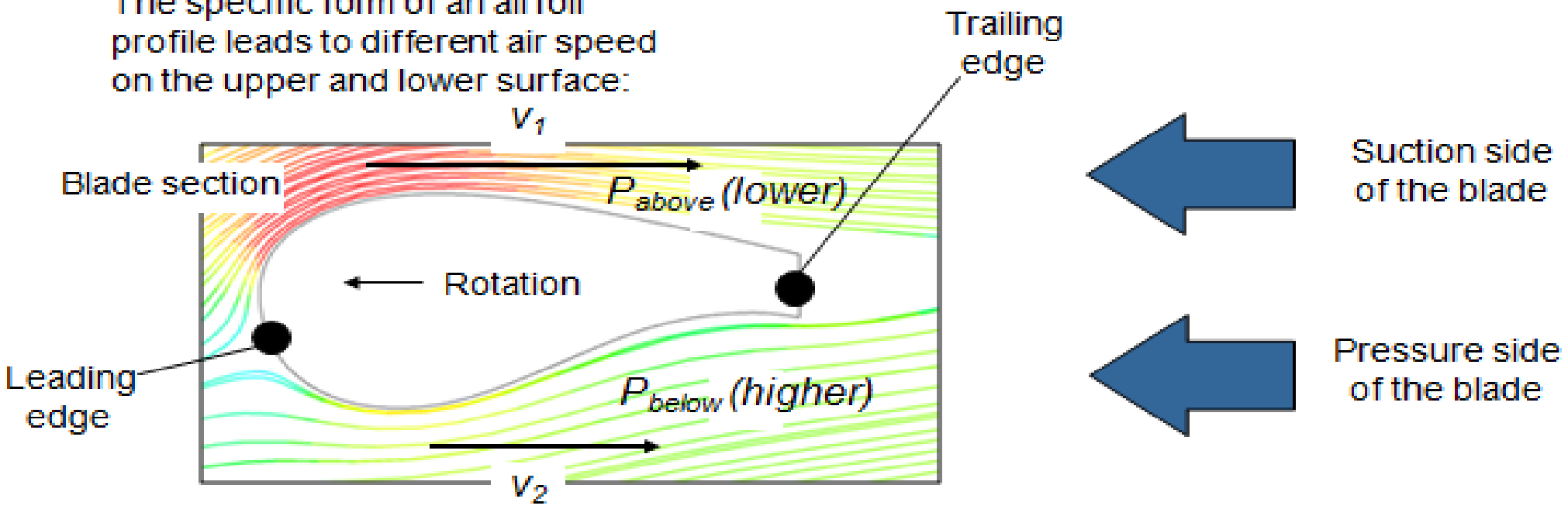






Wind and Power

The specific form of an airfoil profile leads to different air speed on the upper and lower surface:

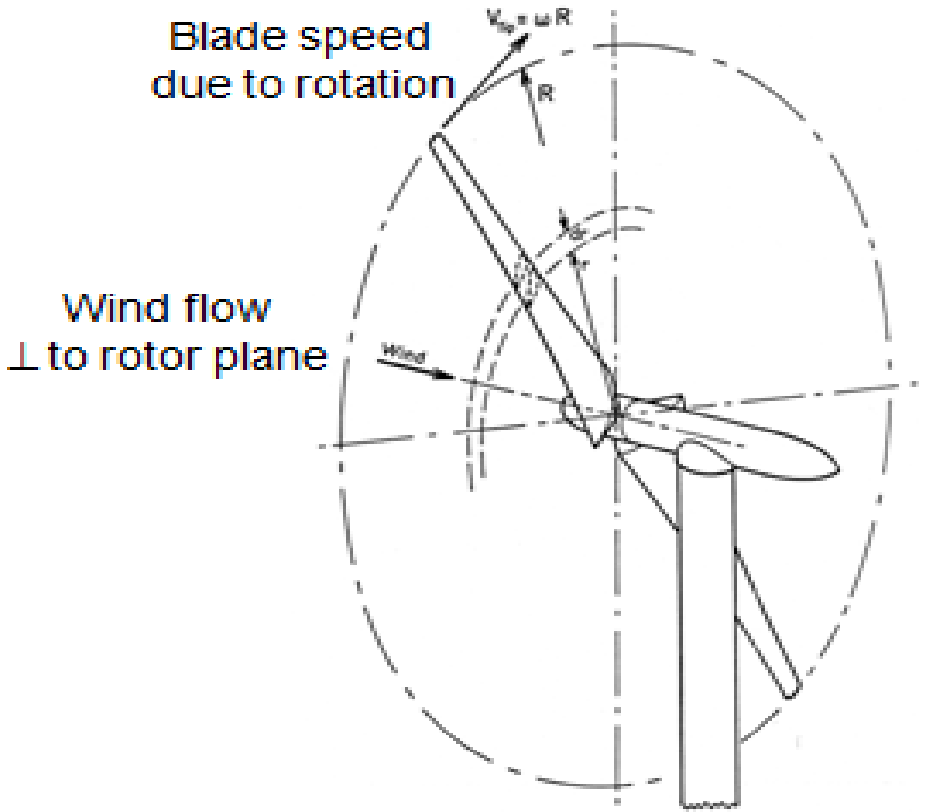


By Bernoulli's Law, $\frac{1}{2}v^2 + p/\rho = const$, and due to the geometry of the airfoil, we have that the pressure above the airfoil is lower than the pressure below the airfoil:

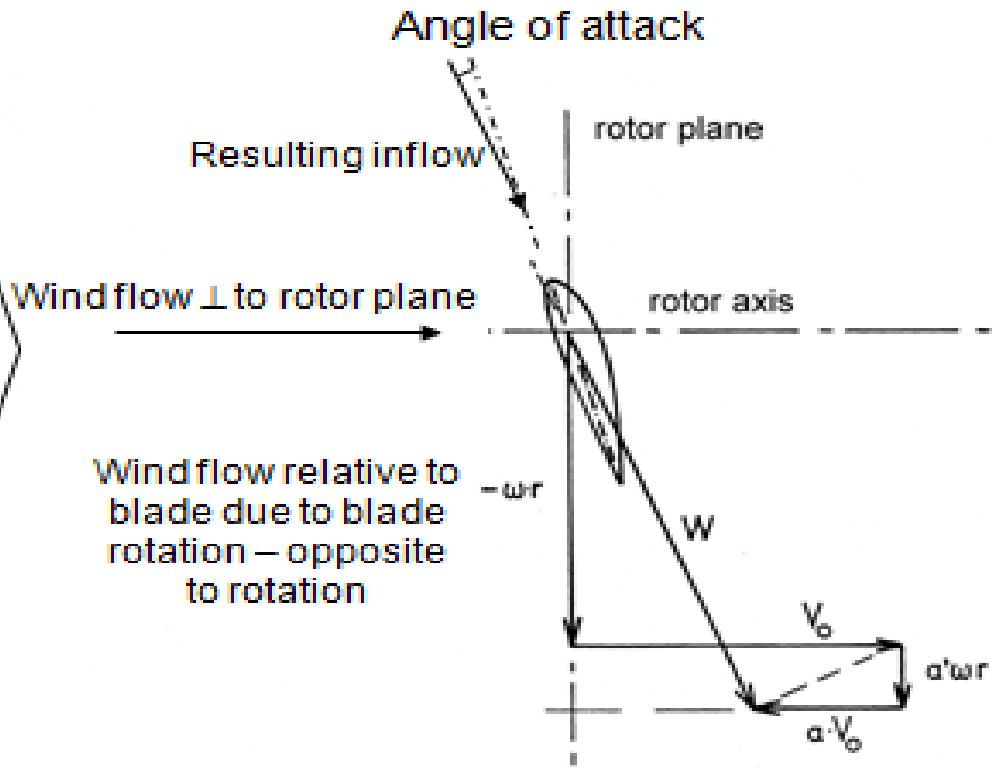
$P_{above} < P_{below}$

Wind and Power

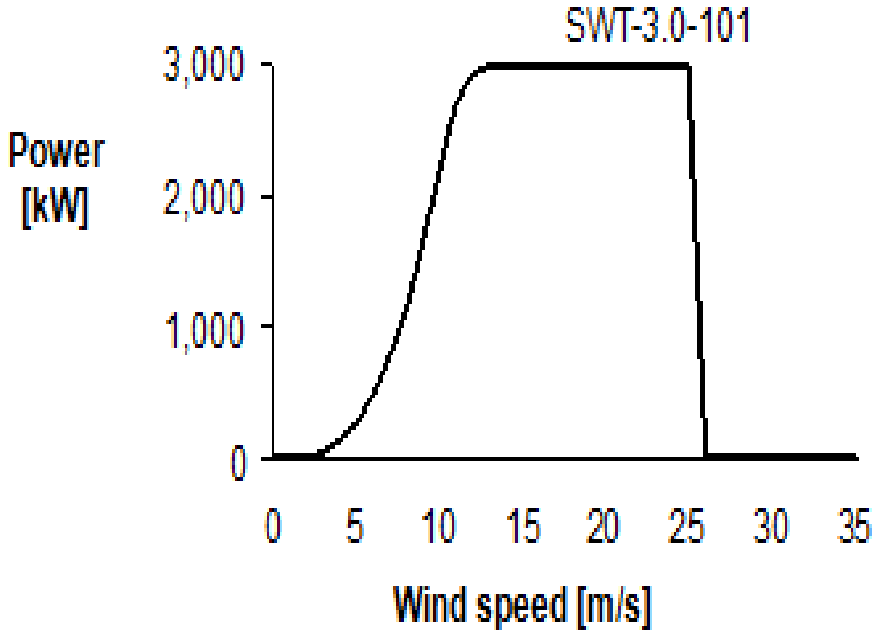
Superposition of wind speed + rotation

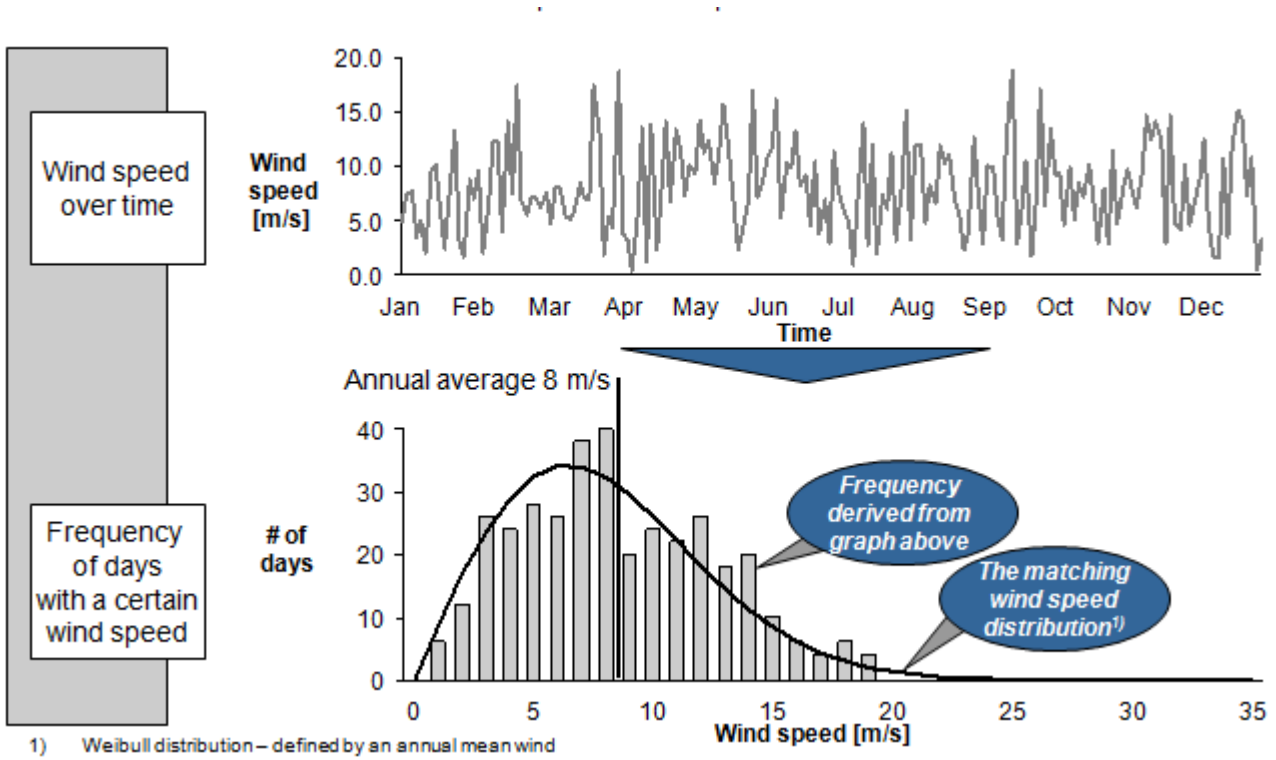


Blade pitch position for optimal angle of attack



Wind and Power

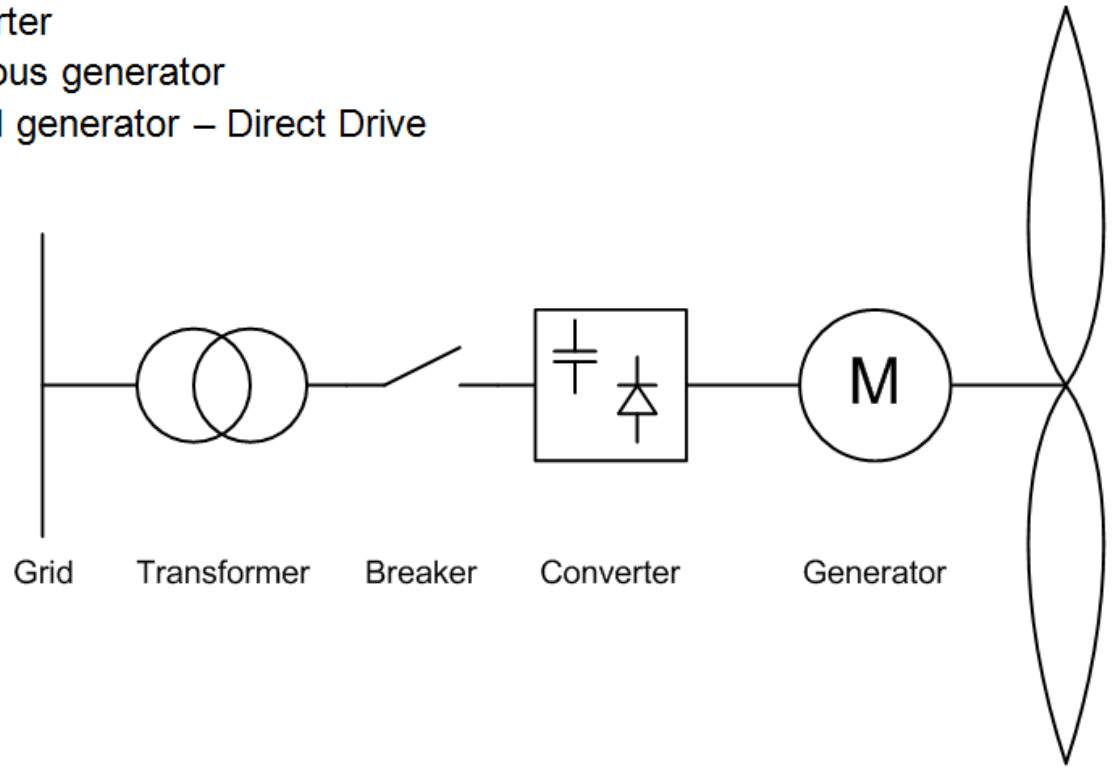




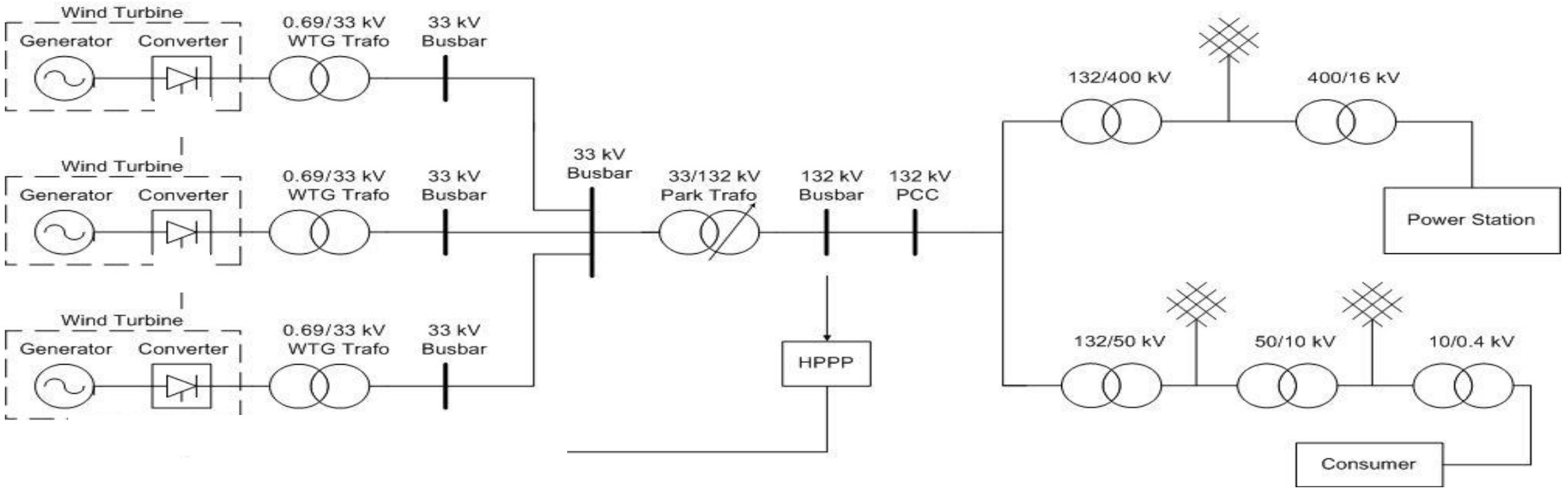
1) Weibull distribution – defined by an annual mean wind

Electricity by Wind Turbine

- full converter
- synchronous generator
- low speed generator – Direct Drive



Electricity by Wind Turbine



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Section:04

Fosil Power Generation and Gas Turbines

PopQuiz #02

- Convert chemical energy into mechanical energy.
- Convert mechanical energy into electric energy.
- Convert thermal energy into electric energy.
- Convert chemical energy into electric energy.

What is the function of a power plant?

PopQuiz #02

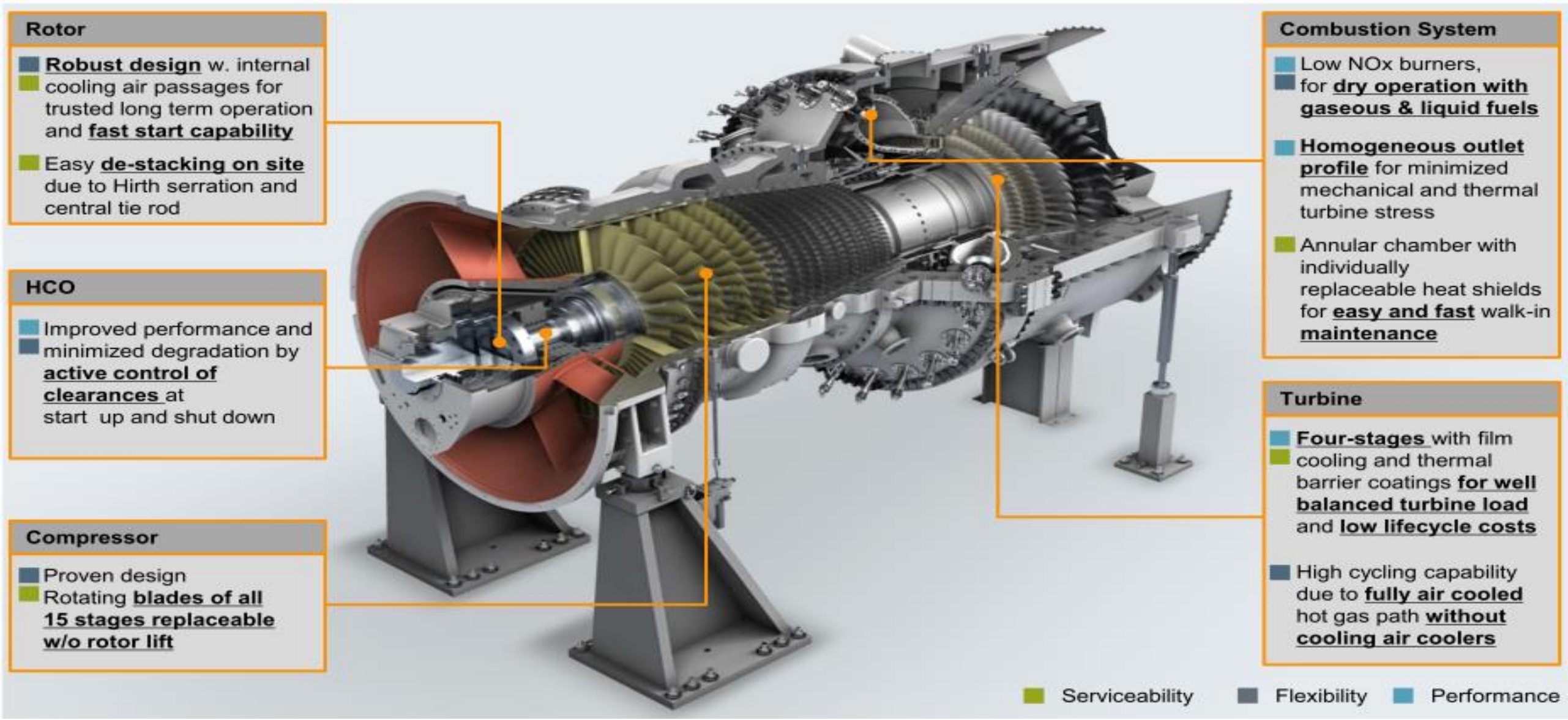
What is the function of a power plant?

- ○ Convert chemical energy into mechanical energy.
- ○ Convert mechanical energy into electric energy.
- ○ Convert thermal energy into electric energy.
- ● Convert chemical energy into electric energy.

Correct

Well done, this is the right answer!

Gas Turbine



Rotor

- **Robust design** w. internal cooling air passages for trusted long term operation and **fast start capability**
- Easy **de-stacking on site** due to Hirth serration and central tie rod

HCO

- Improved performance and minimized degradation by **active control of clearances** at start up and shut down

Compressor

- Proven design
- Rotating **blades of all 15 stages replaceable w/o rotor lift**

Combustion System

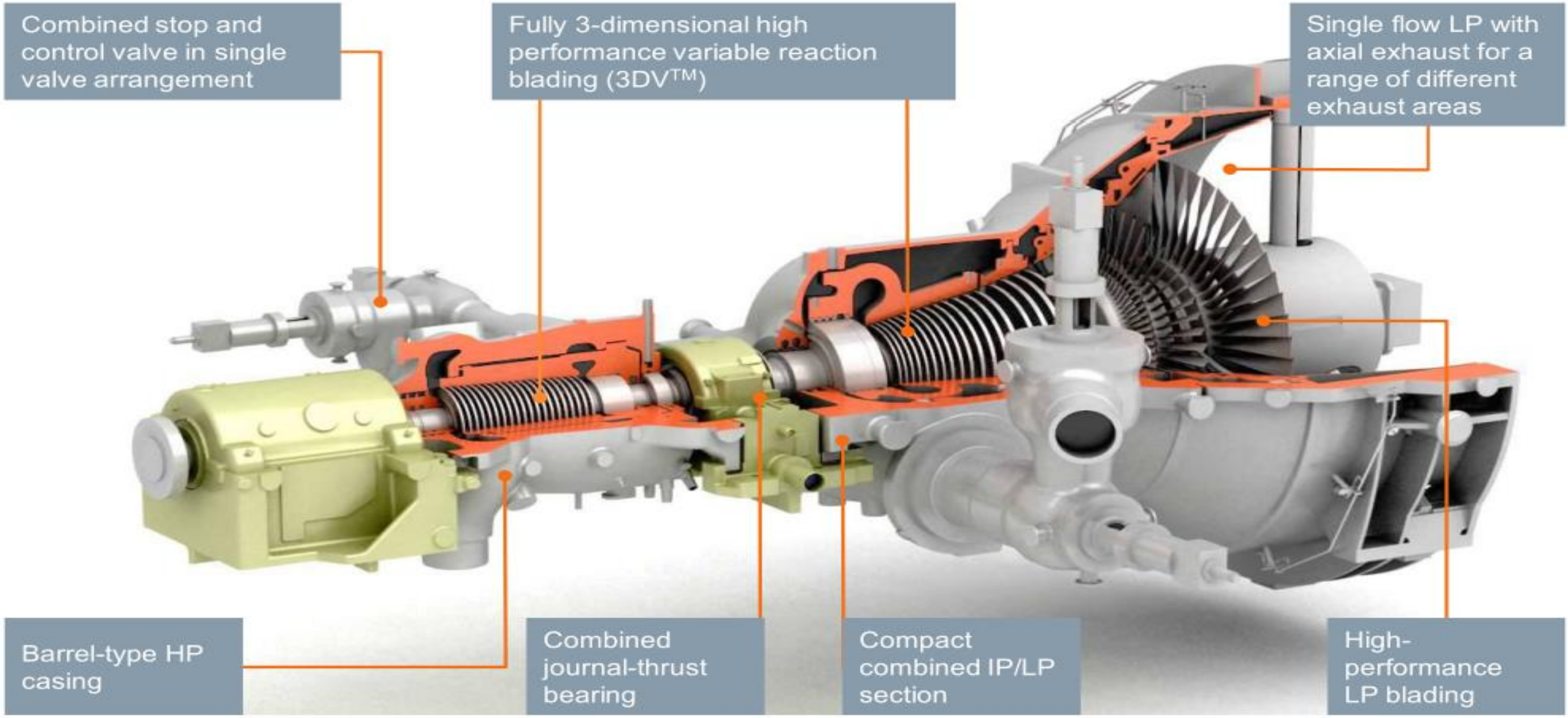
- Low NOx burners, for **dry operation with gaseous & liquid fuels**
- **Homogeneous outlet profile** for minimized mechanical and thermal turbine stress
- Annular chamber with individually replaceable heat shields for **easy and fast** walk-in **maintenance**

Turbine

- **Four-stages** with film cooling and thermal barrier coatings **for well balanced turbine load** and **low lifecycle costs**
- High cycling capability due to **fully air cooled** hot gas path **without cooling air coolers**

Serviceability Flexibility Performance

Steam Turbine



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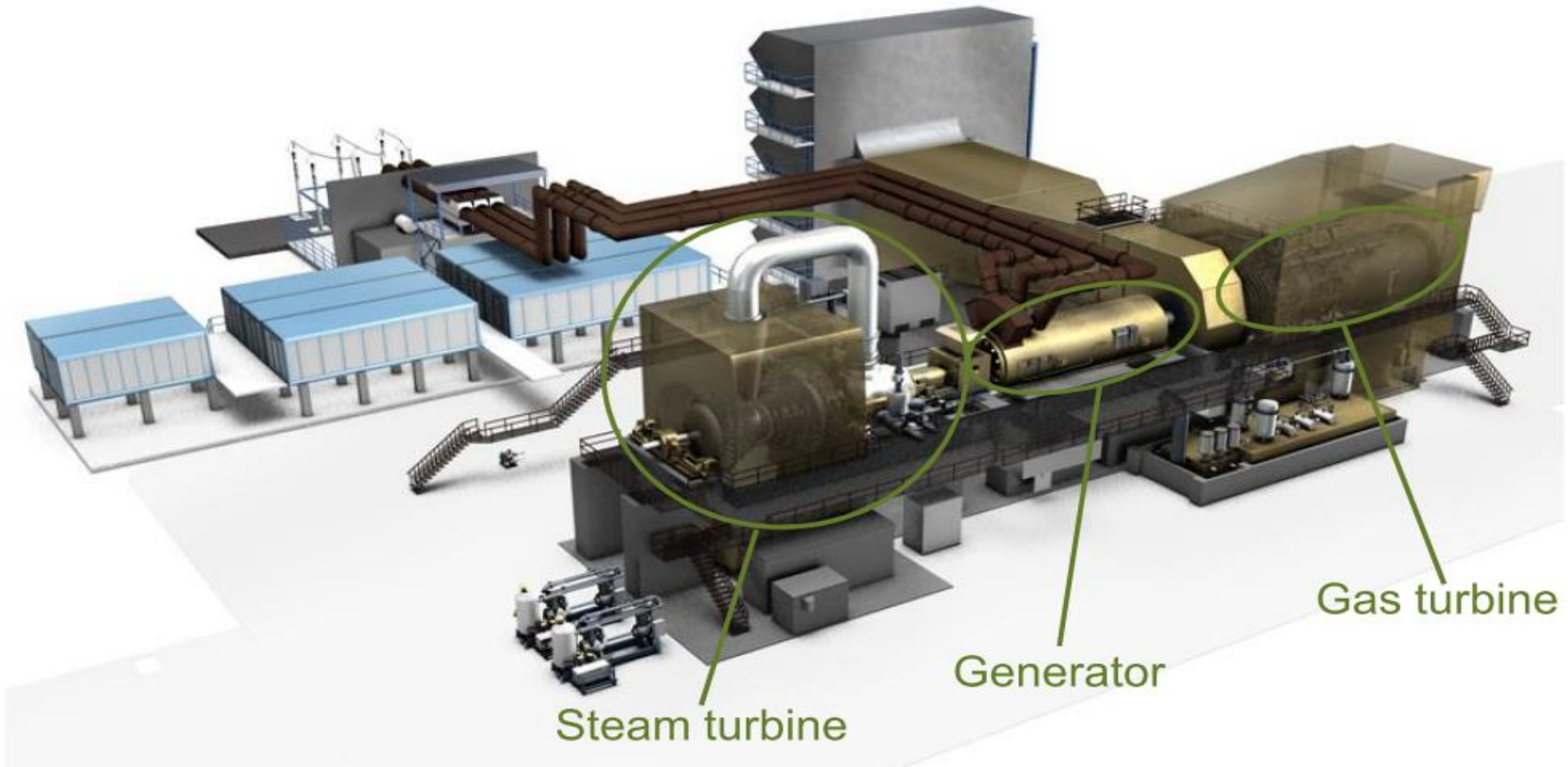
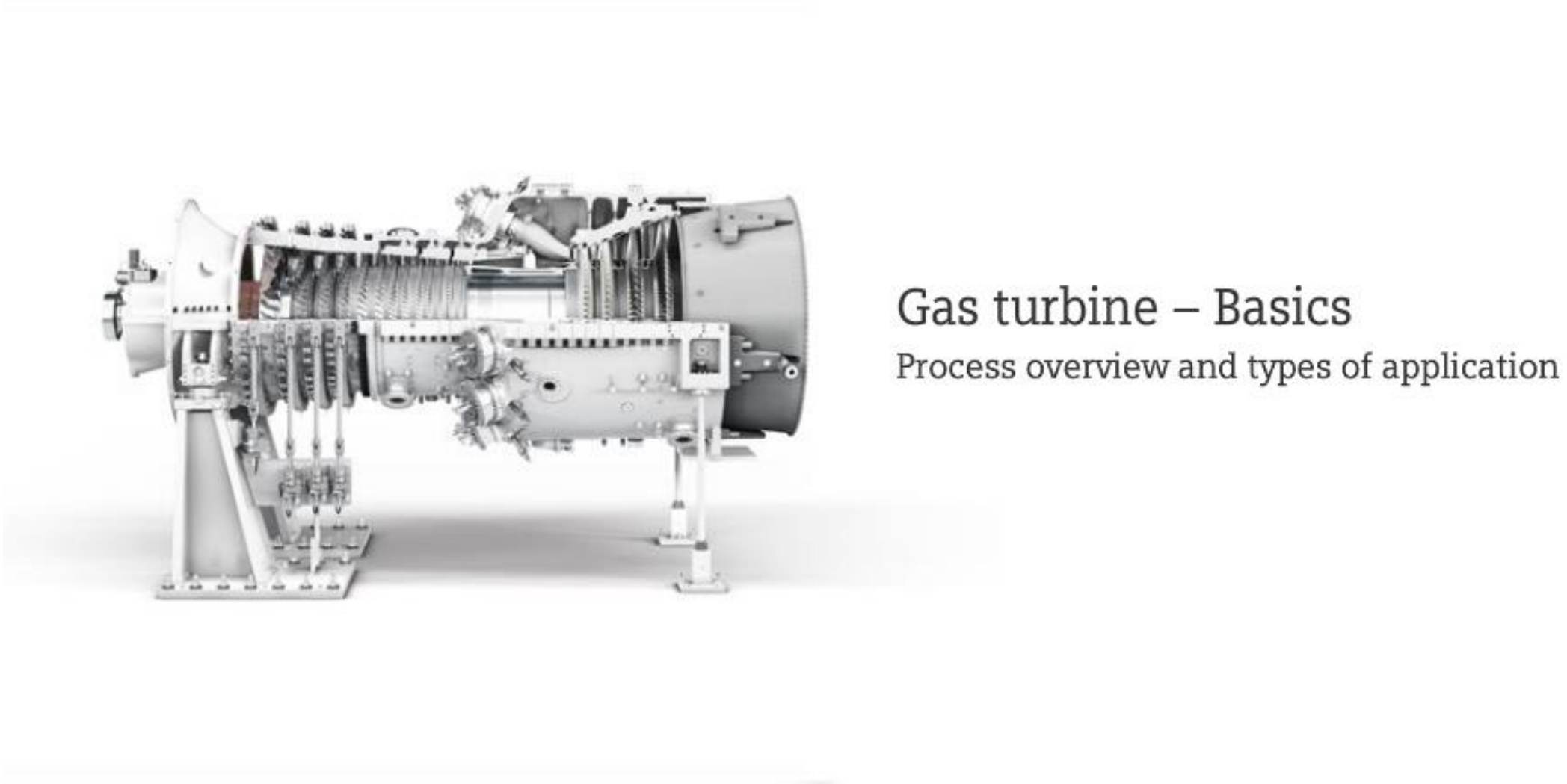
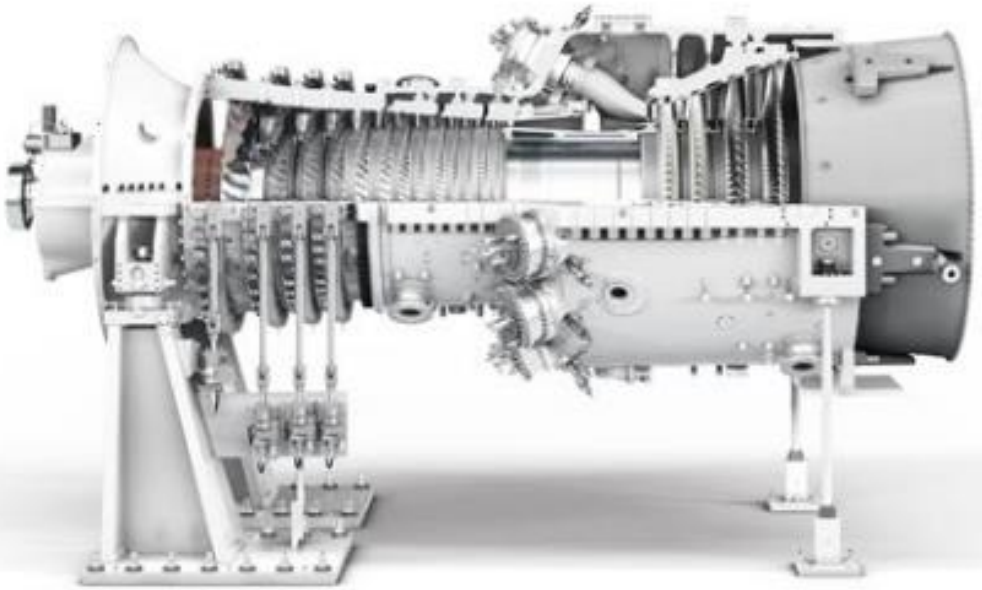
Combined Cycle Power Plant



Gas Turbine Basics



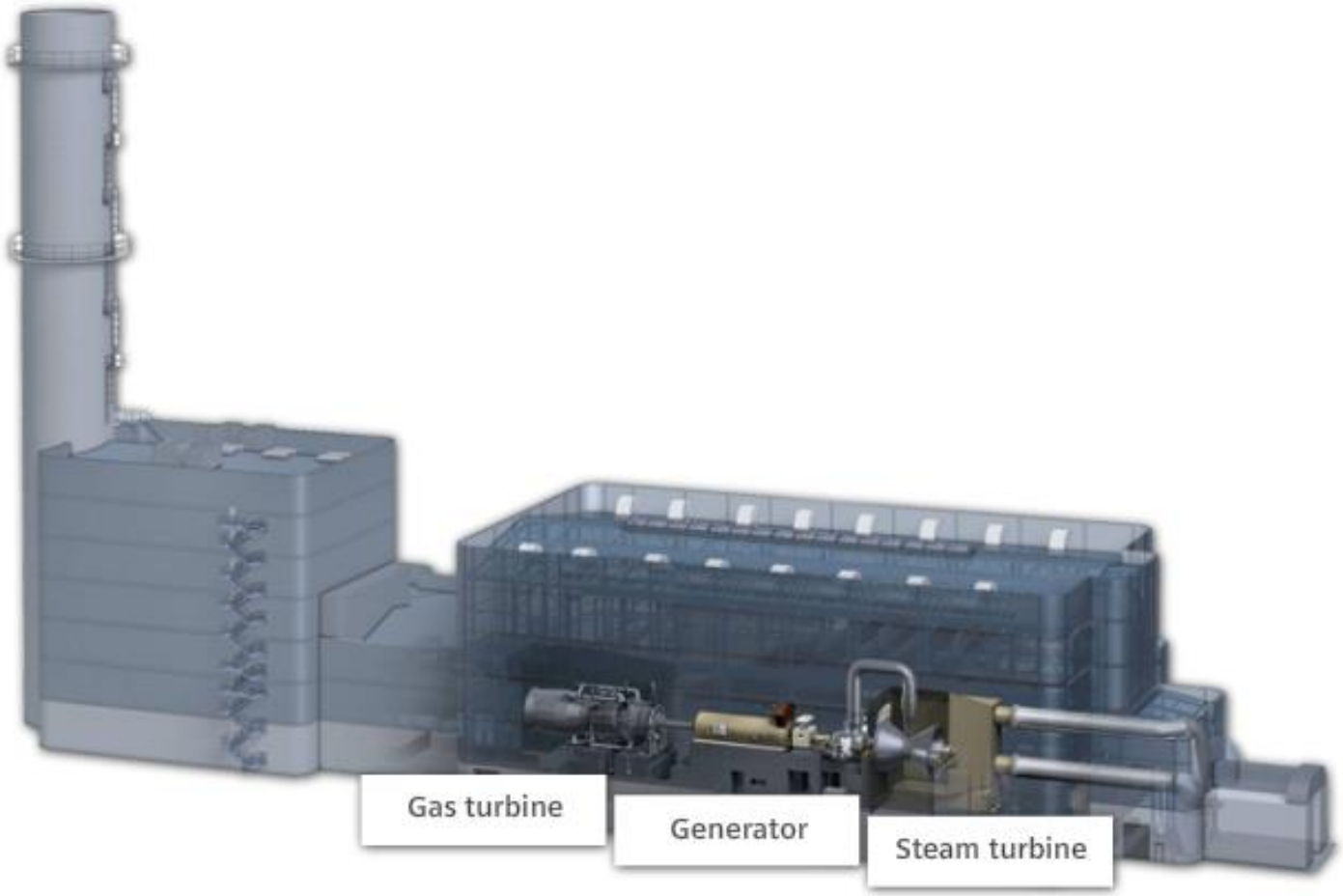
Gas Turbine Basics



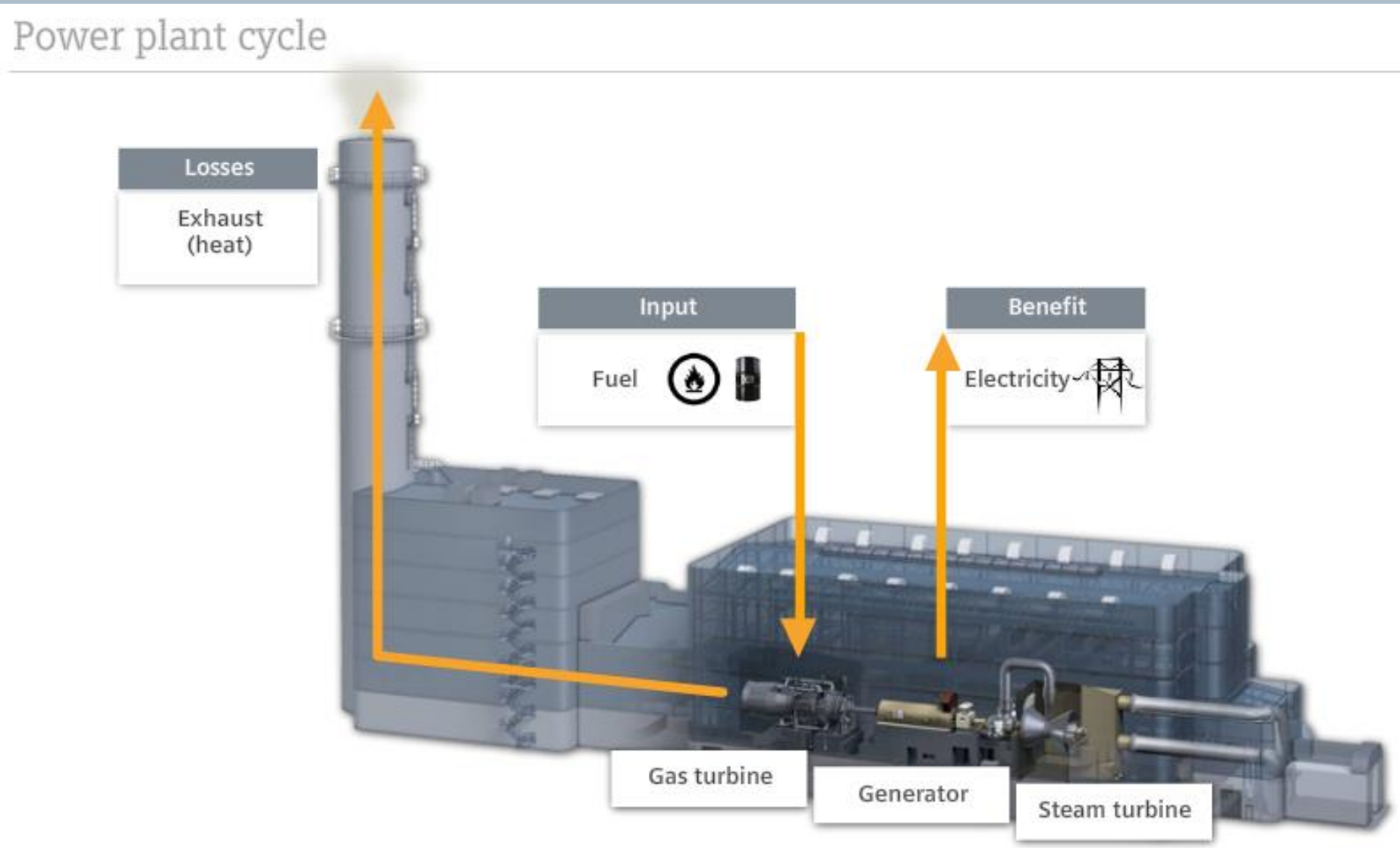
- Process overview
- Gas turbine applications
- Gas turbine models

Gas Turbine Basics

Power plant cycle

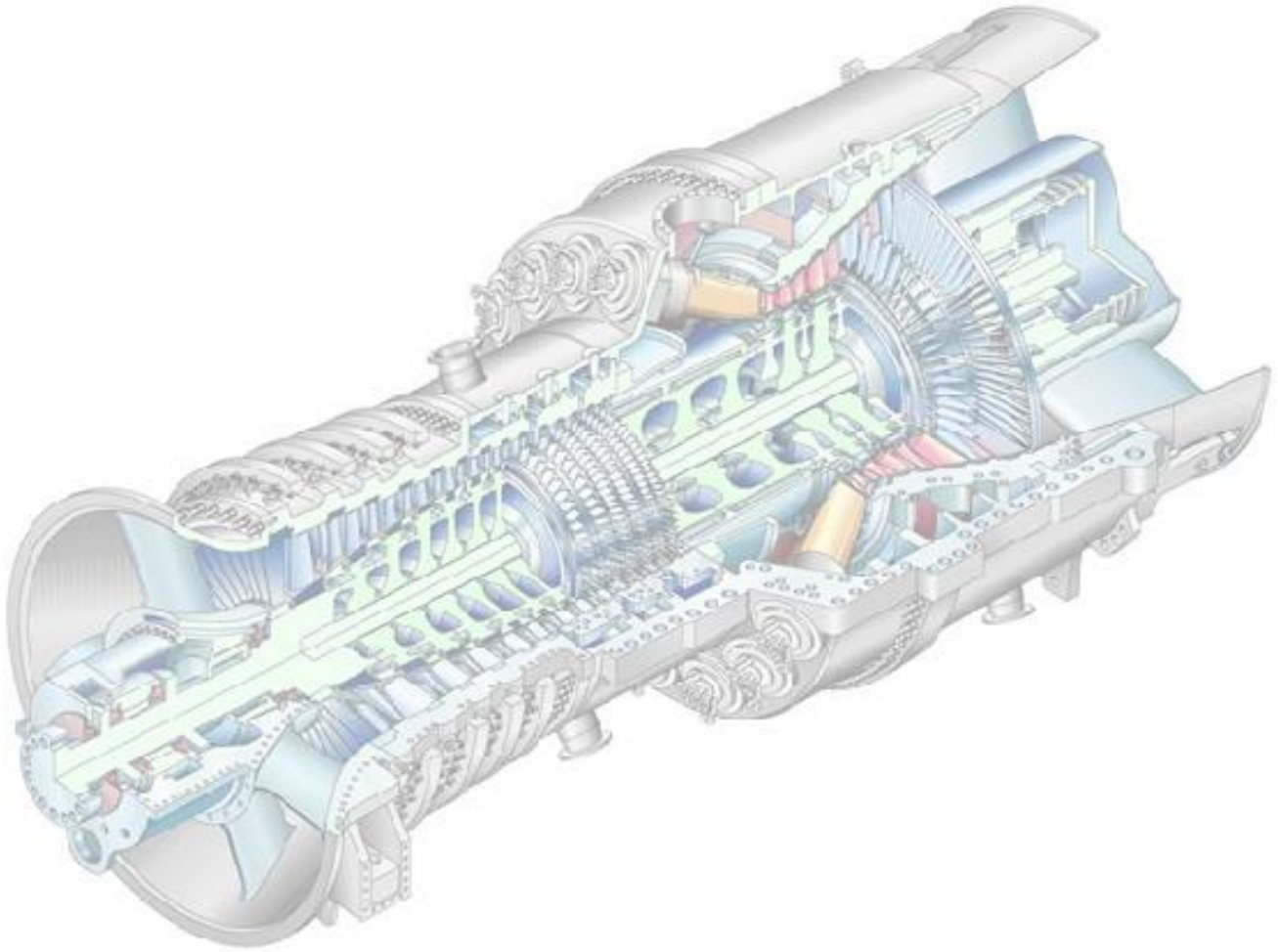


Gas Turbine Basics



Gas Turbine Basics

Process sequences in the gas turbine



Gas Turbine Basics

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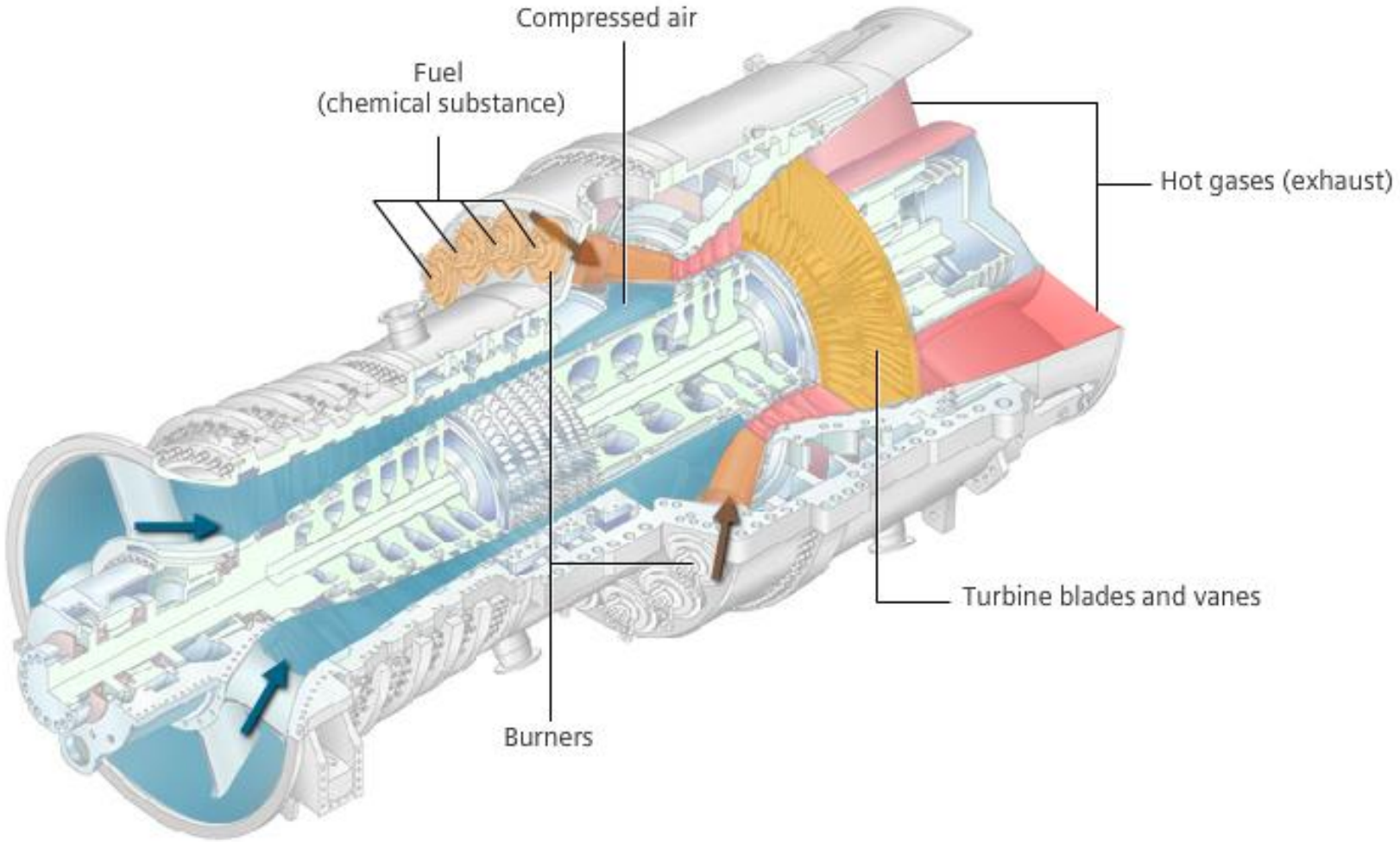
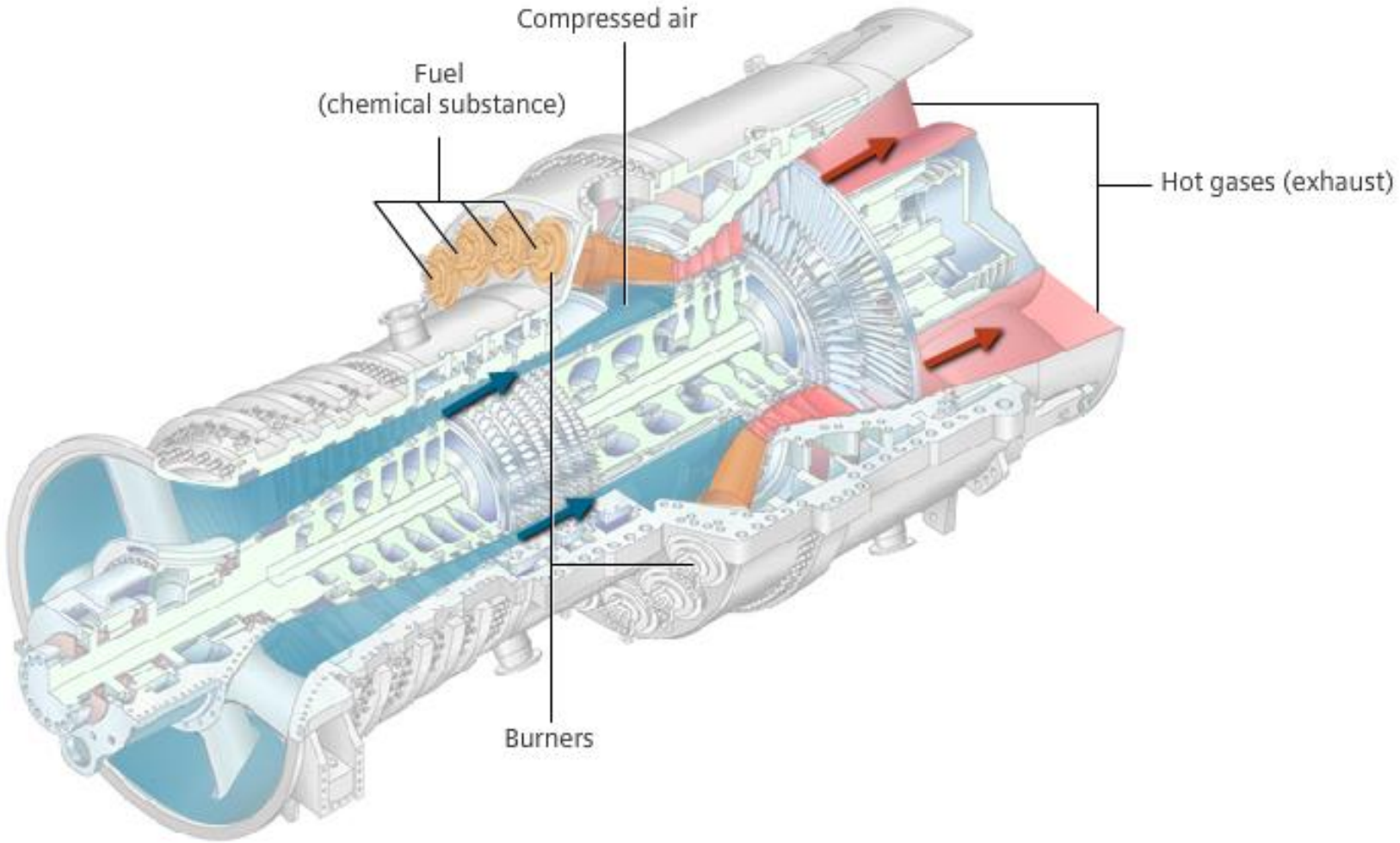


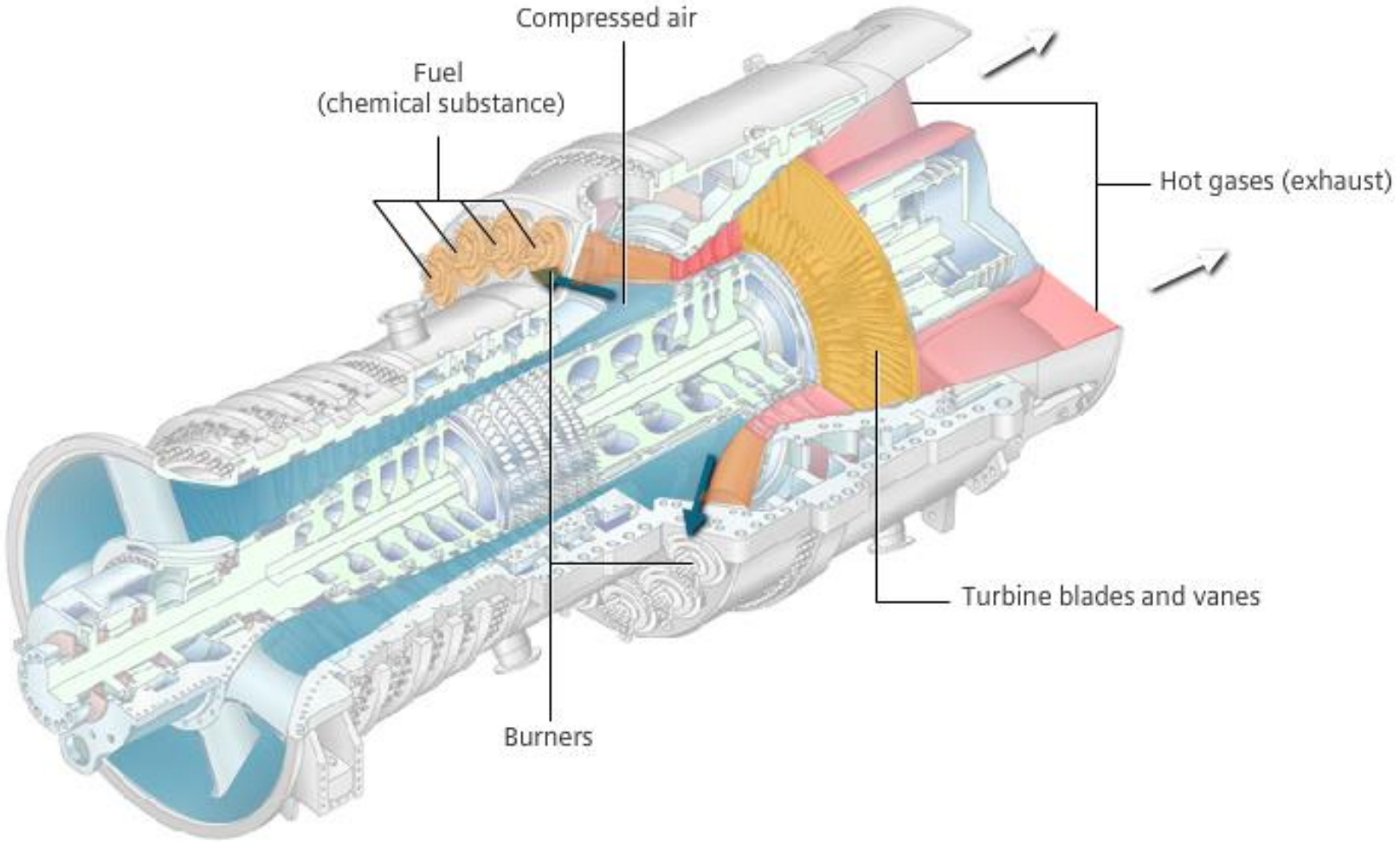
Gas Turbine Basics

Process sequences in the gas turbine



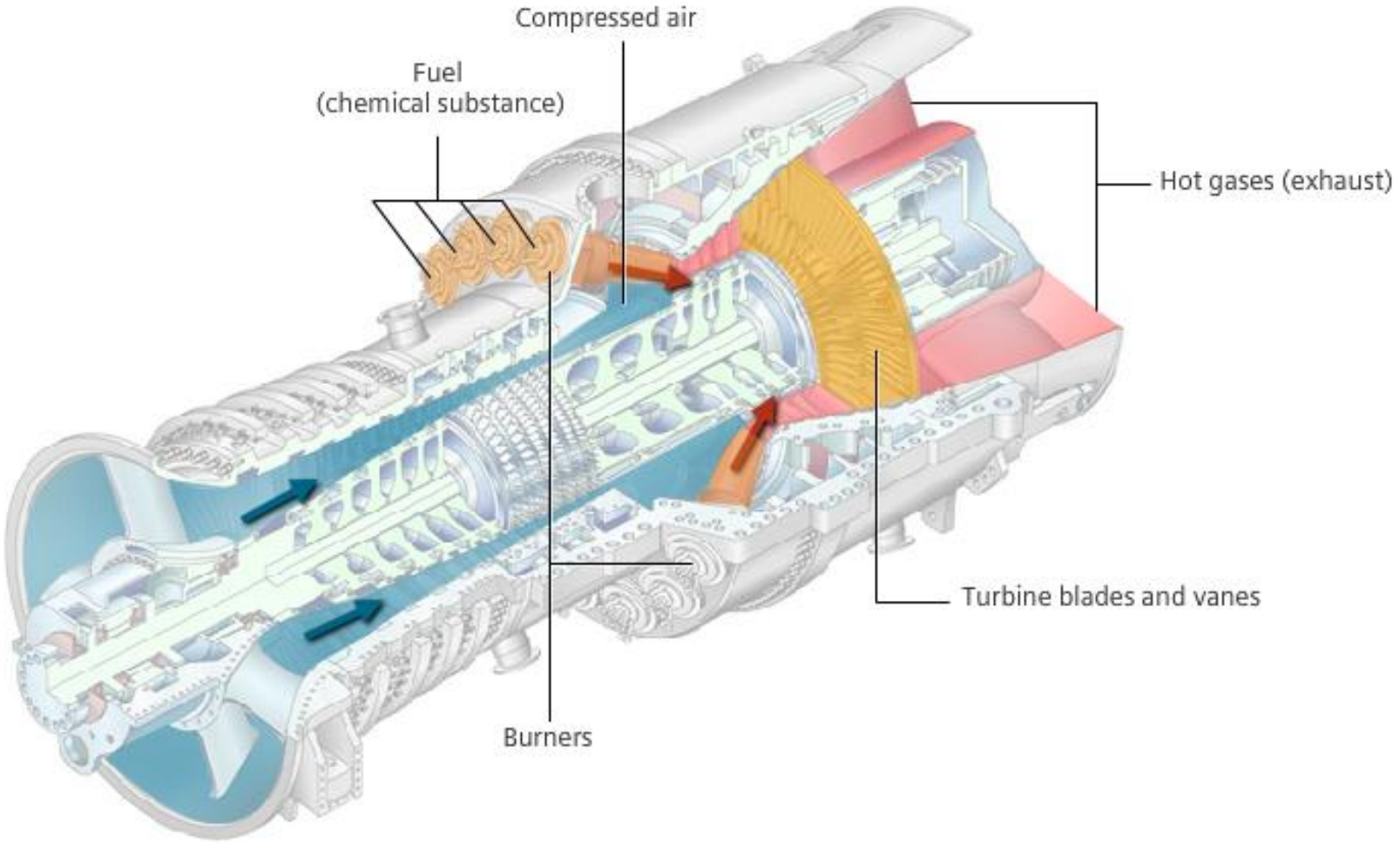
Gas Turbine Basics

Process sequences in the gas turbine



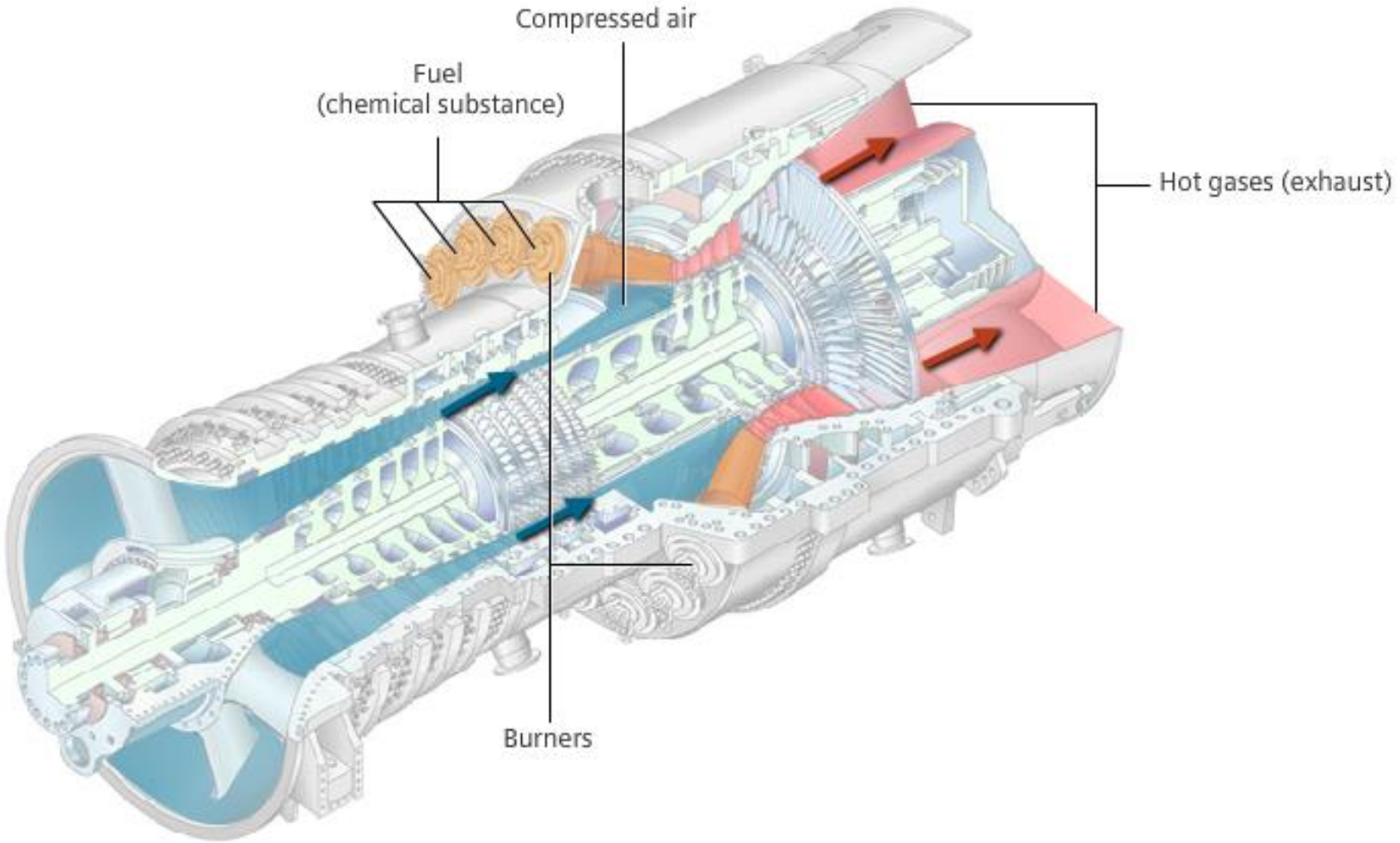
Gas Turbine Basics

Process sequences in the gas turbine



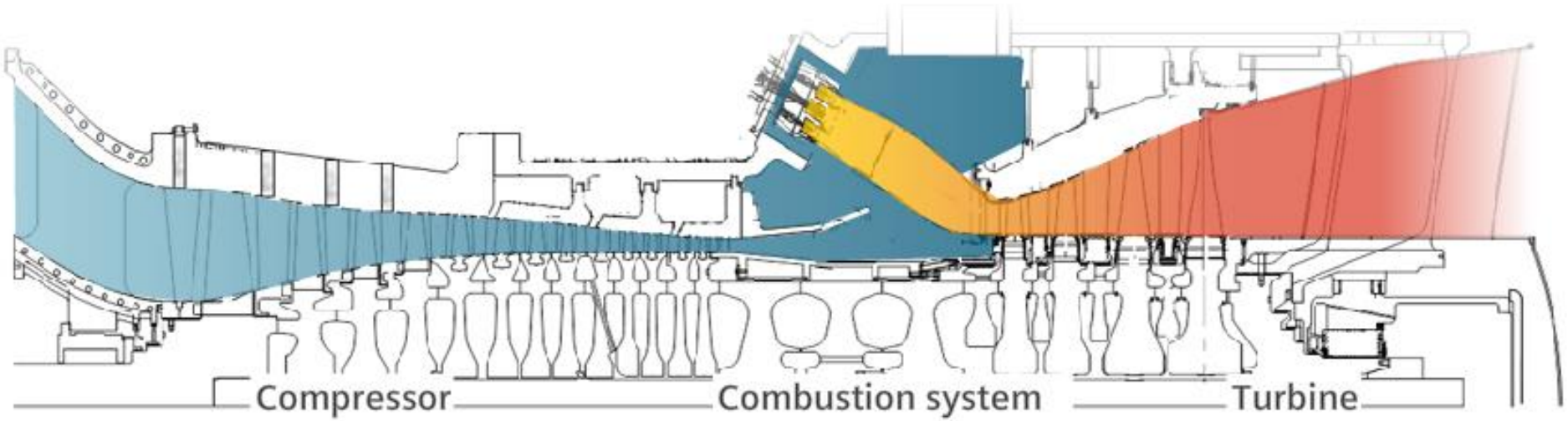
Gas Turbine Basics

Process sequences in the gas turbine



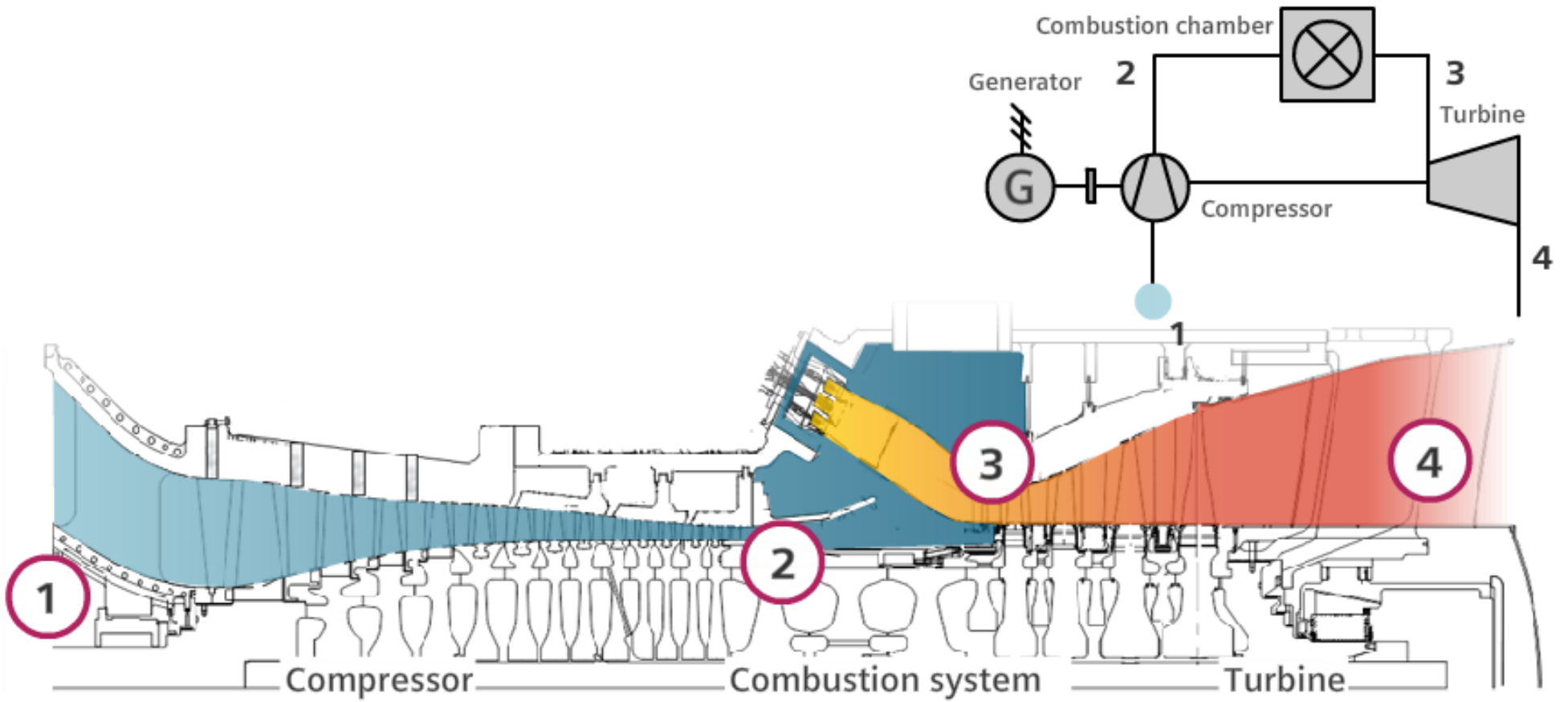
Gas Turbine Basics

Energy conversion processes



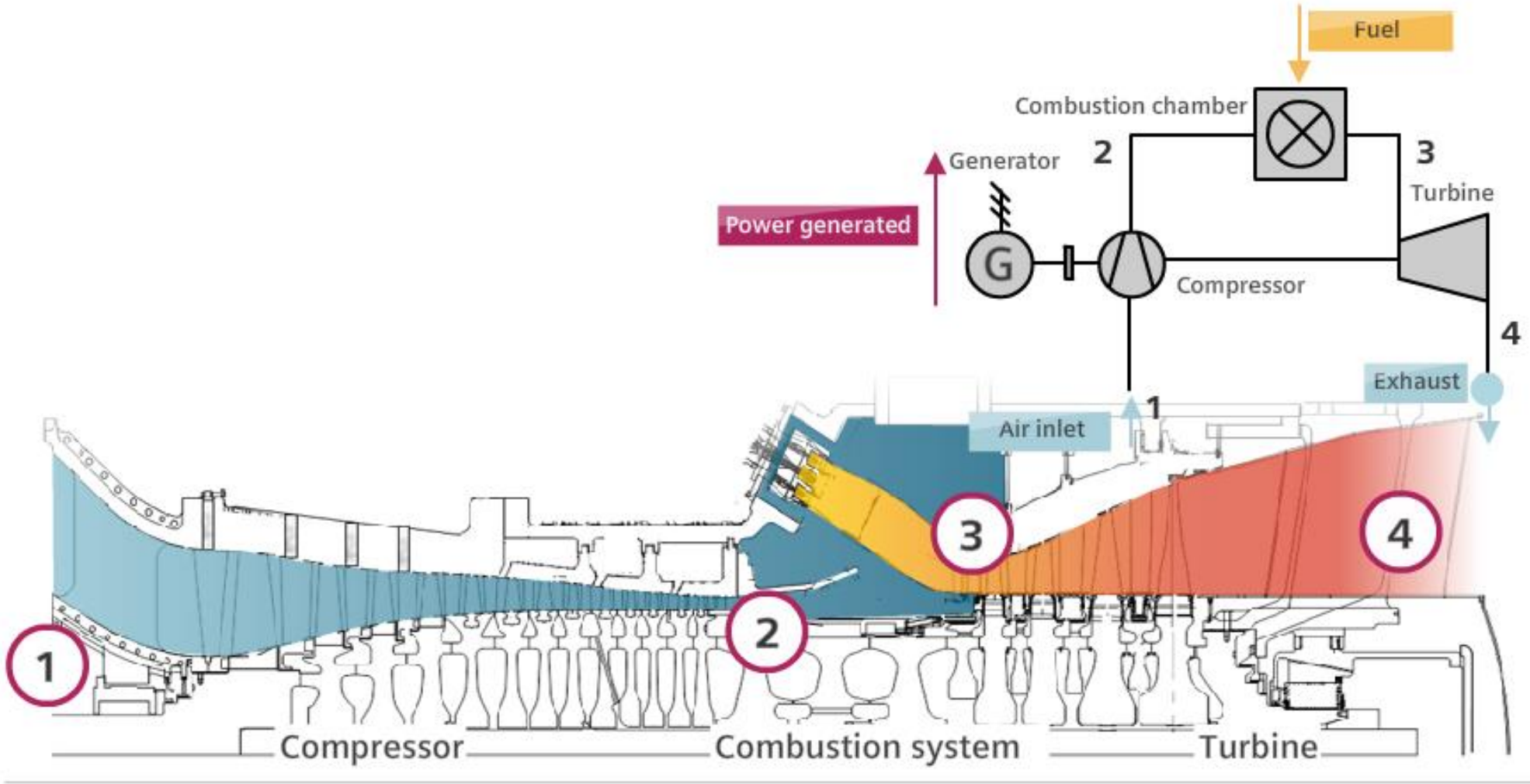
Gas Turbine Basics

Energy conversion processes



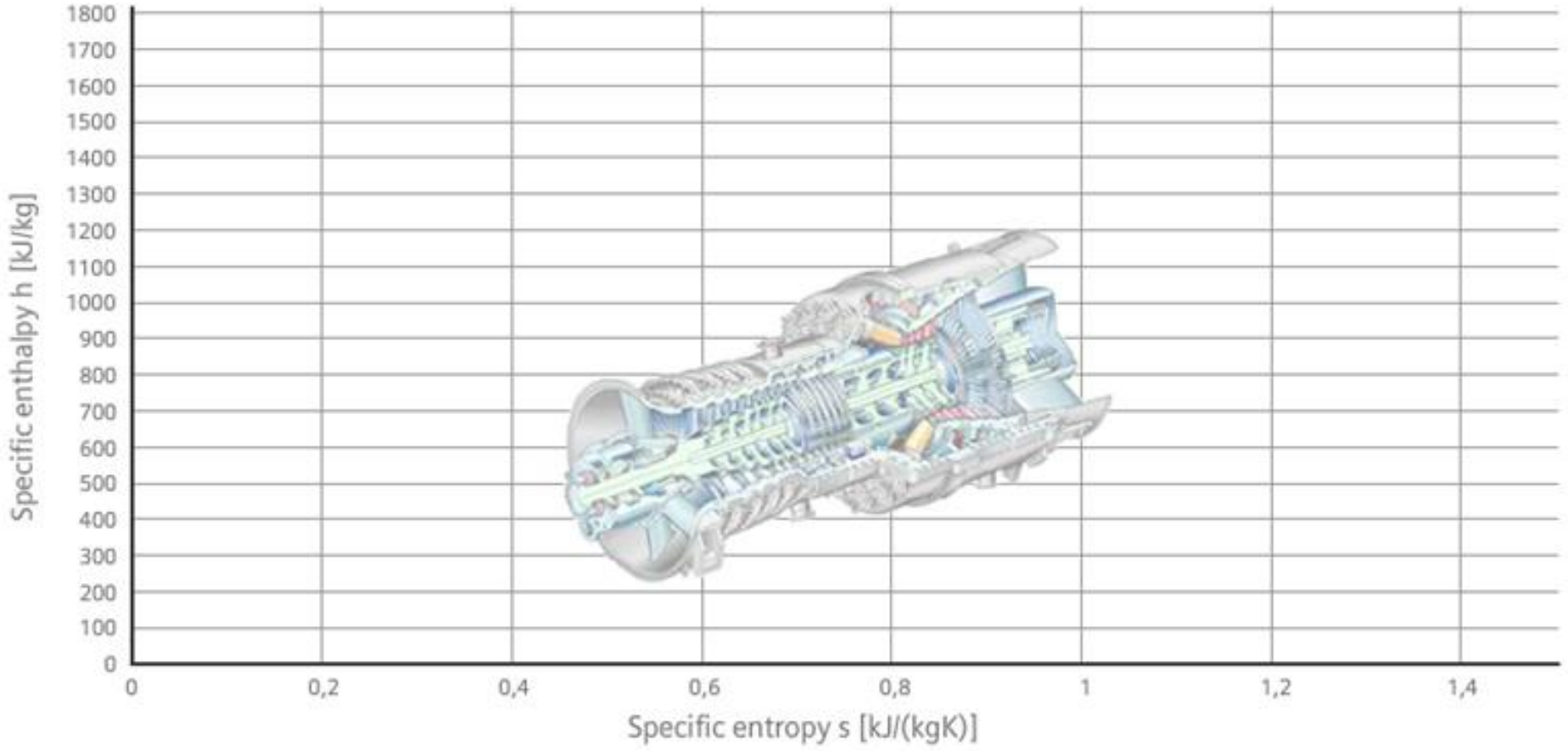
Gas Turbine Basics

Energy conversion processes



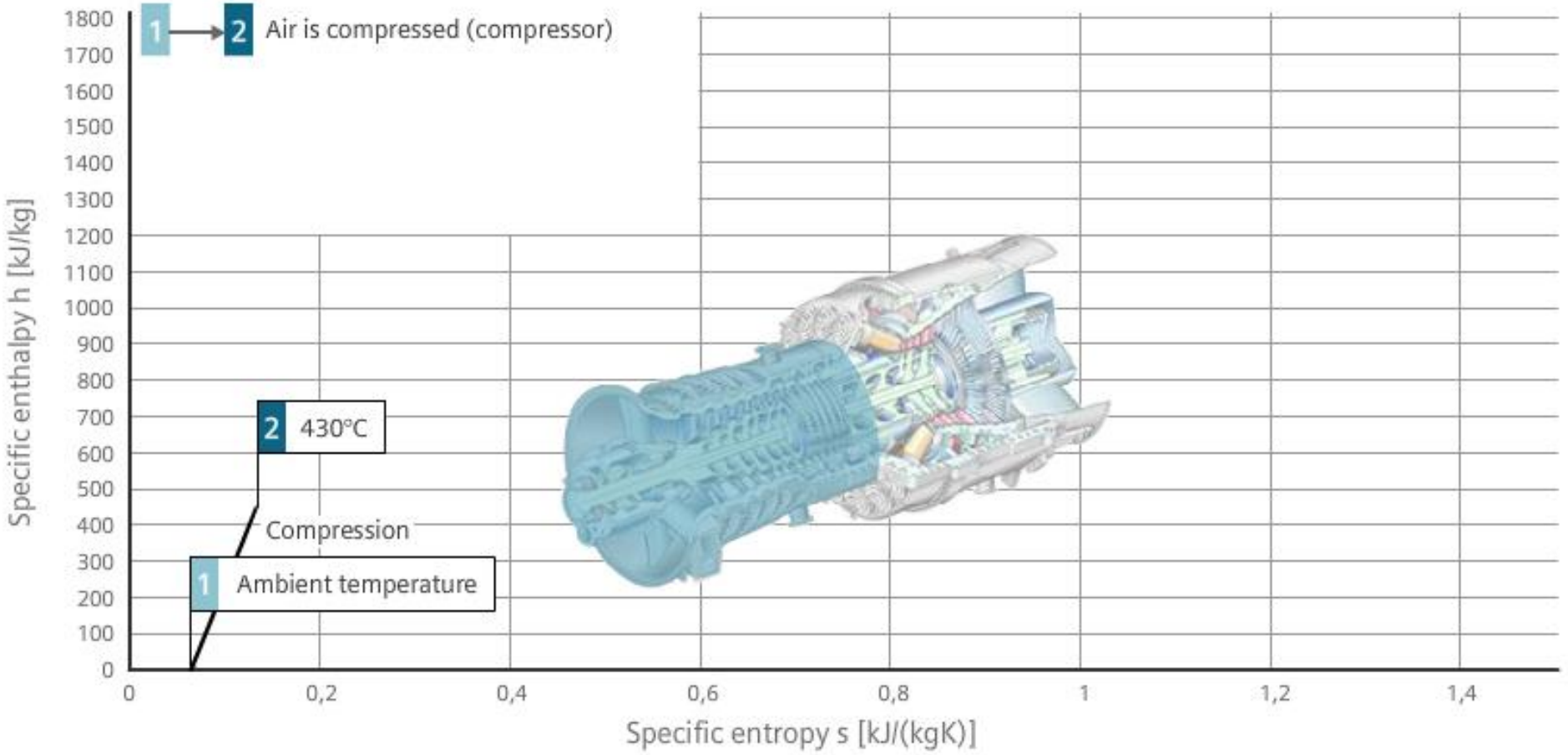
Gas Turbine Basics

Mollier diagram – h-s diagram



Gas Turbine Basics

Mollier diagram – h-s diagram



Gas Turbine Basics

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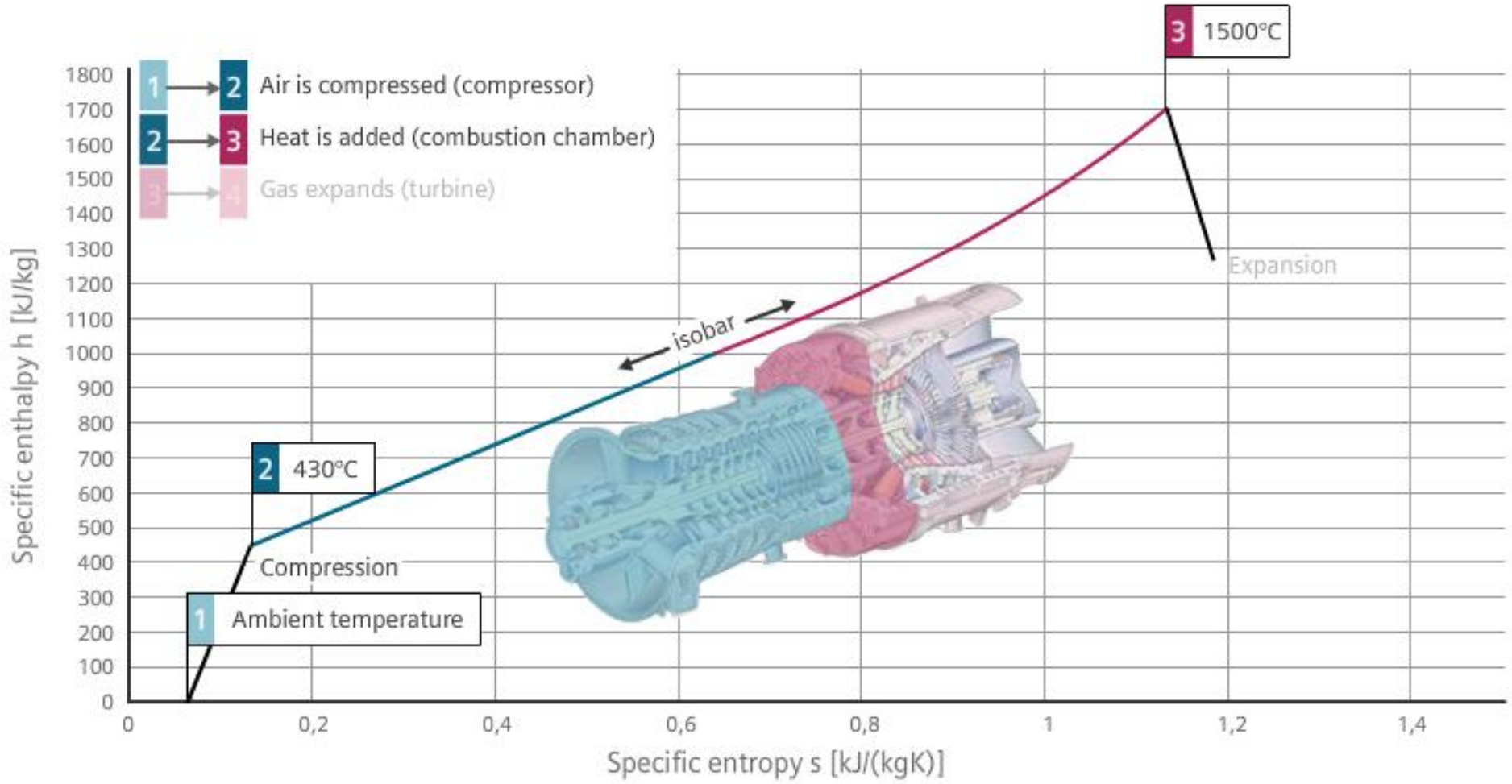
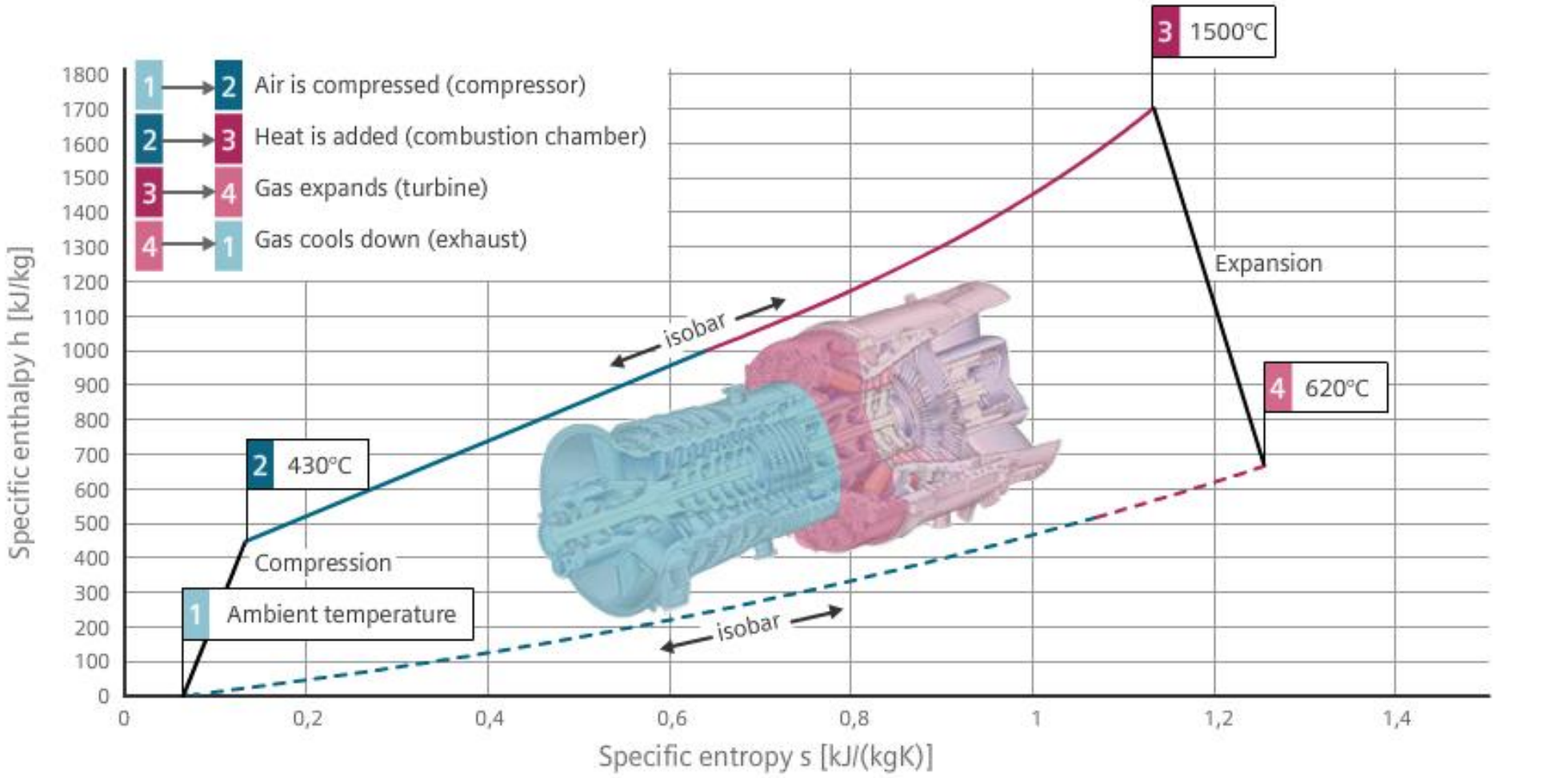
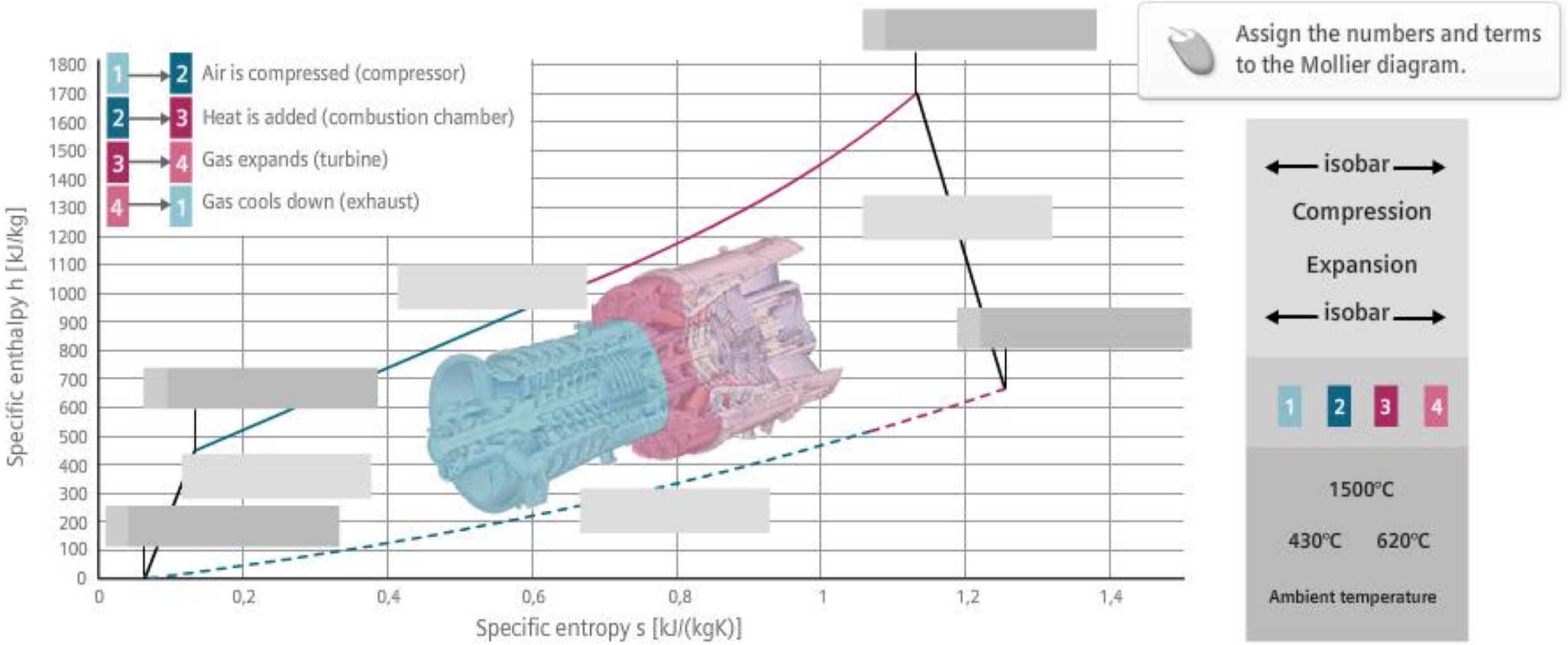


Gas Turbine Basics

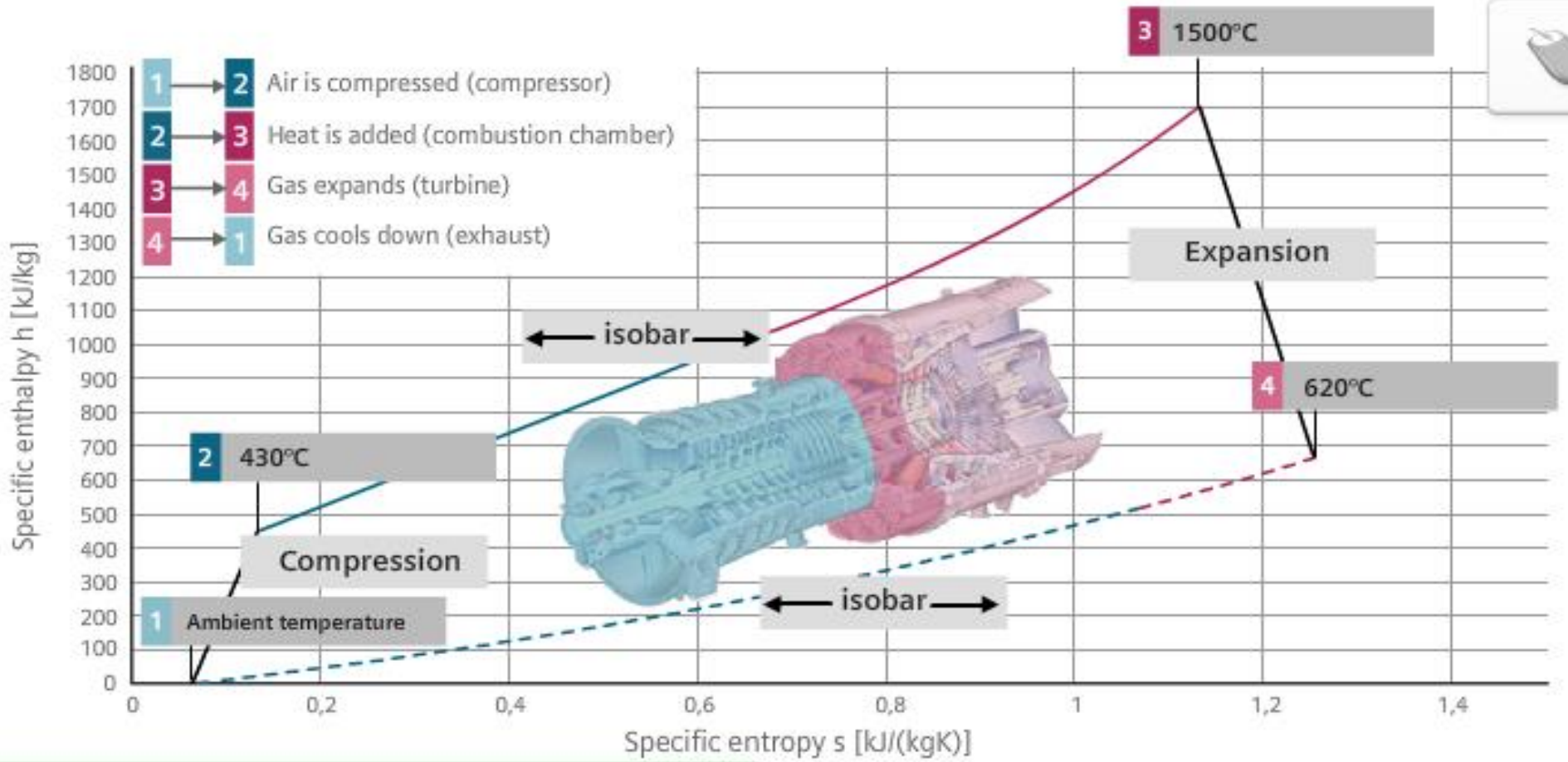
Mollier diagram – h-s diagram



PopQuiz #03


Assign the numbers and terms to the Mollier diagram.
1 → 2 Air is compressed (compressor)
2 → 3 Heat is added (combustion chamber)
3 → 4 Gas expands (turbine)
4 → 1 Gas cools down (exhaust)
Specific enthalpy h [kJ/kg]
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
0,2
0,4
0,6
0,8
1
1,2
1,4
Specific entropy s [kJ/(kgK)]
isobar
Compression
Expansion
isobar
1
2
3
4
1500°C
430°C
620°C
Ambient temperature

PopQuiz #03



Assign the numbers and terms to the Mollier diagram.

Correct

Well done, this is the correct solution.

Gas Turbine Basics

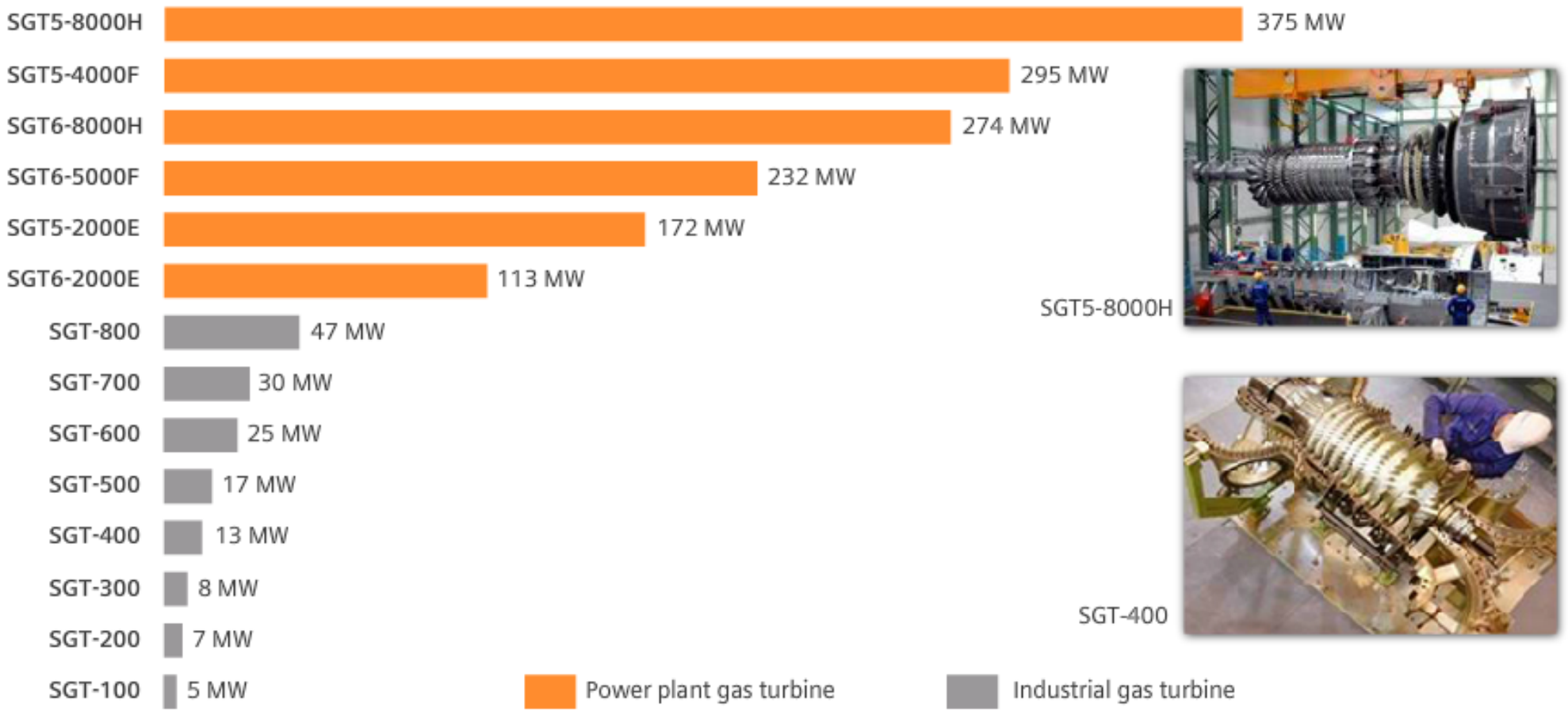
Fuels

Gaseous fuels

Liquid fuels

Gas Turbine Basics

Siemens gas turbine – Product lines for 50 Hz and 60 Hz

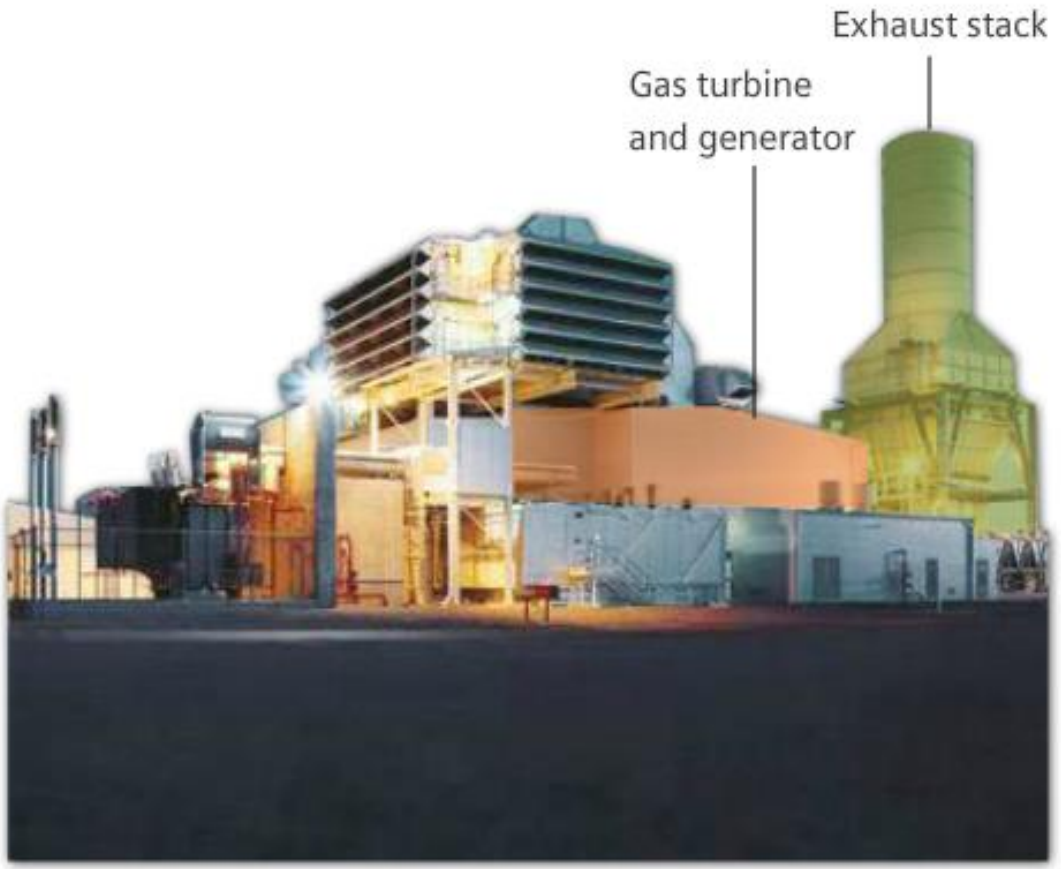


SGT5-8000H

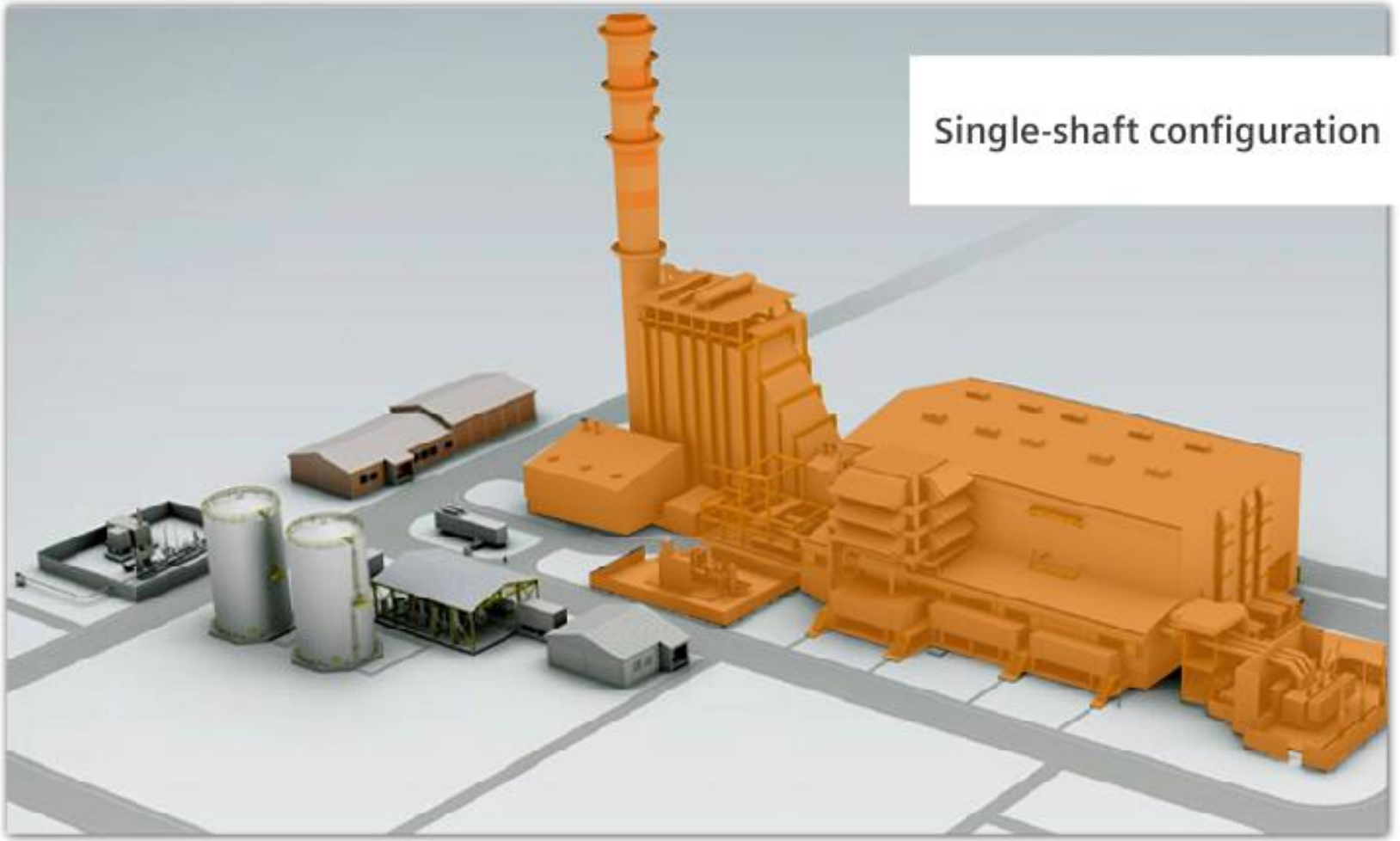
SGT-400

Gas Turbine Basics

Simple-cycle gas turbine power plant

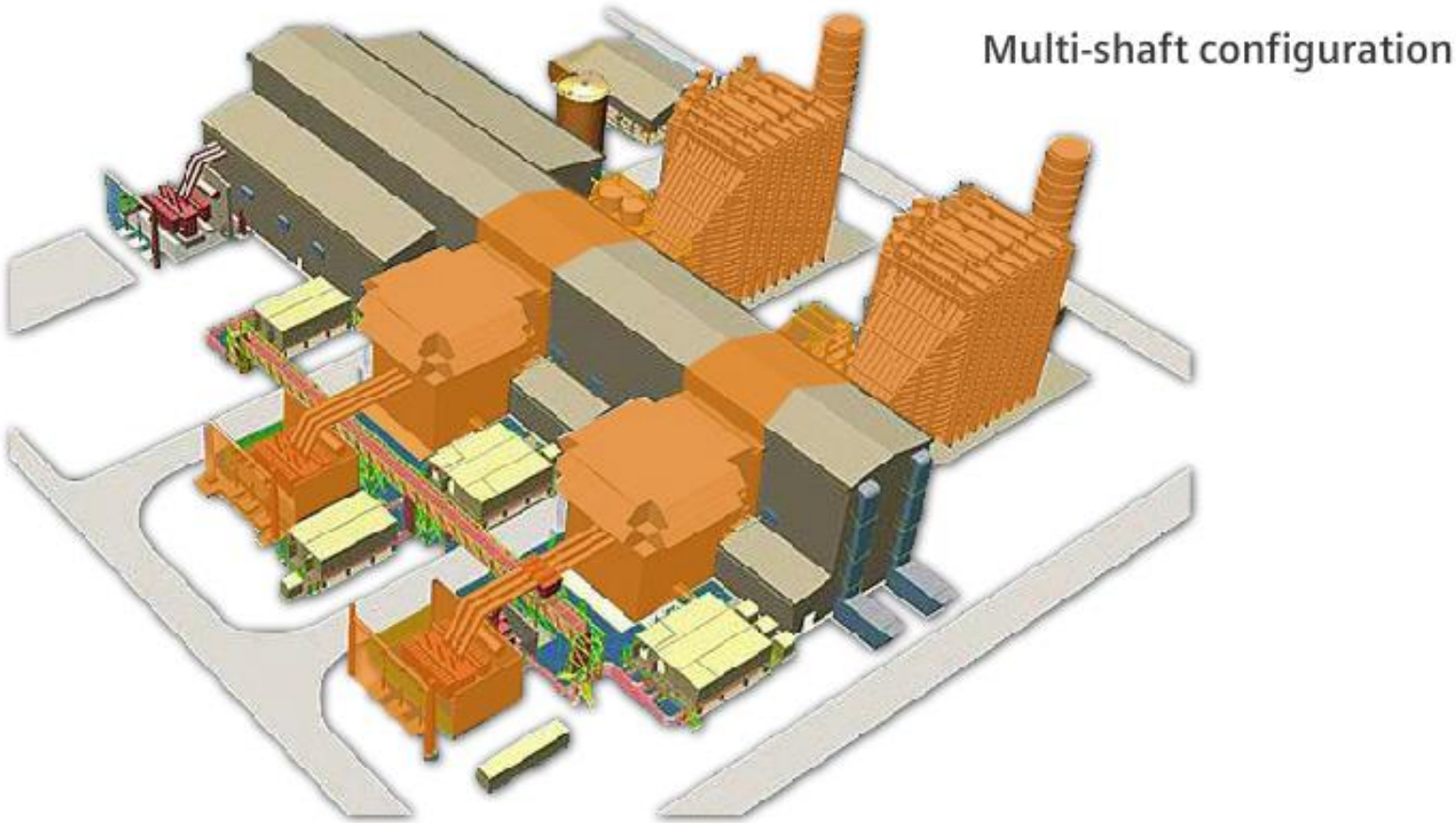


CC plant configurations



Gas Turbine Basics

CC plant configurations



PopQuiz #04

- [ ] Power plant gas turbines
- [ ] Industrial gas turbines
- [ ] Gas turbine power block
- [ ] Power plant gas turbines and steam turbines

In which two product lines for 50 Hz and 60 Hz are gas turbines grouped?

Evaluate

PopQuiz #04

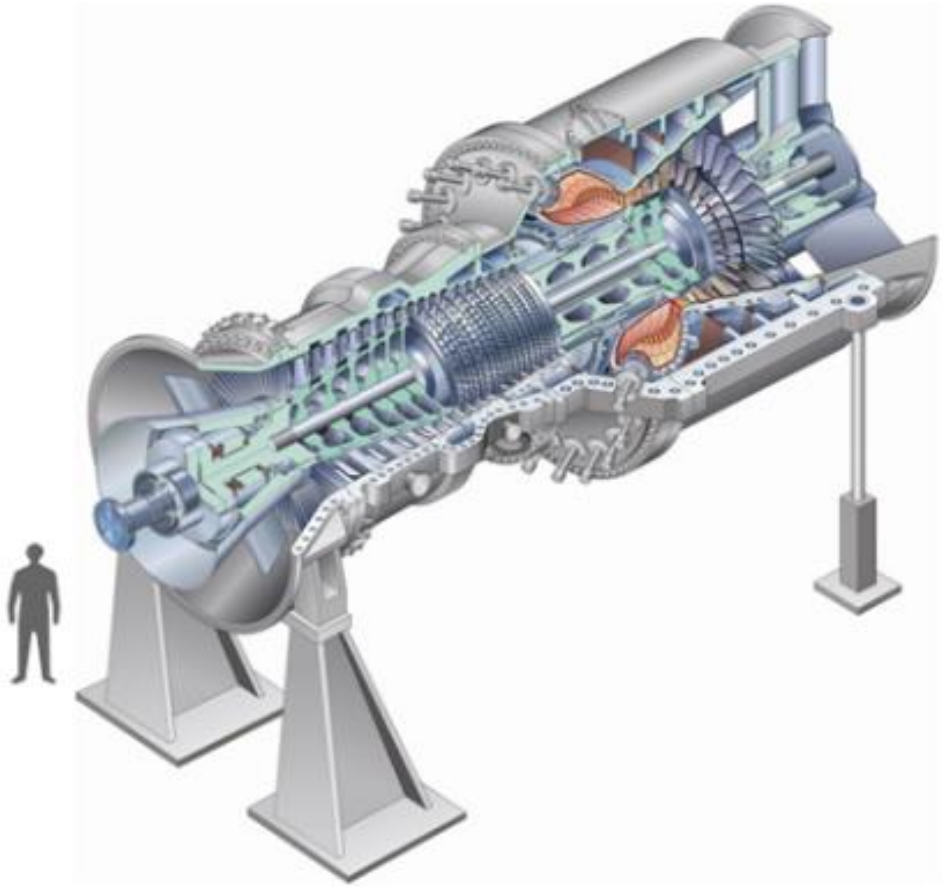
In which two product lines for 50 Hz and 60 Hz are gas turbines grouped?

- [x] Power plant gas turbines
- [x] Industrial gas turbines
- [ ] Gas turbine power block
- [ ] Power plant gas turbines and steam turbines

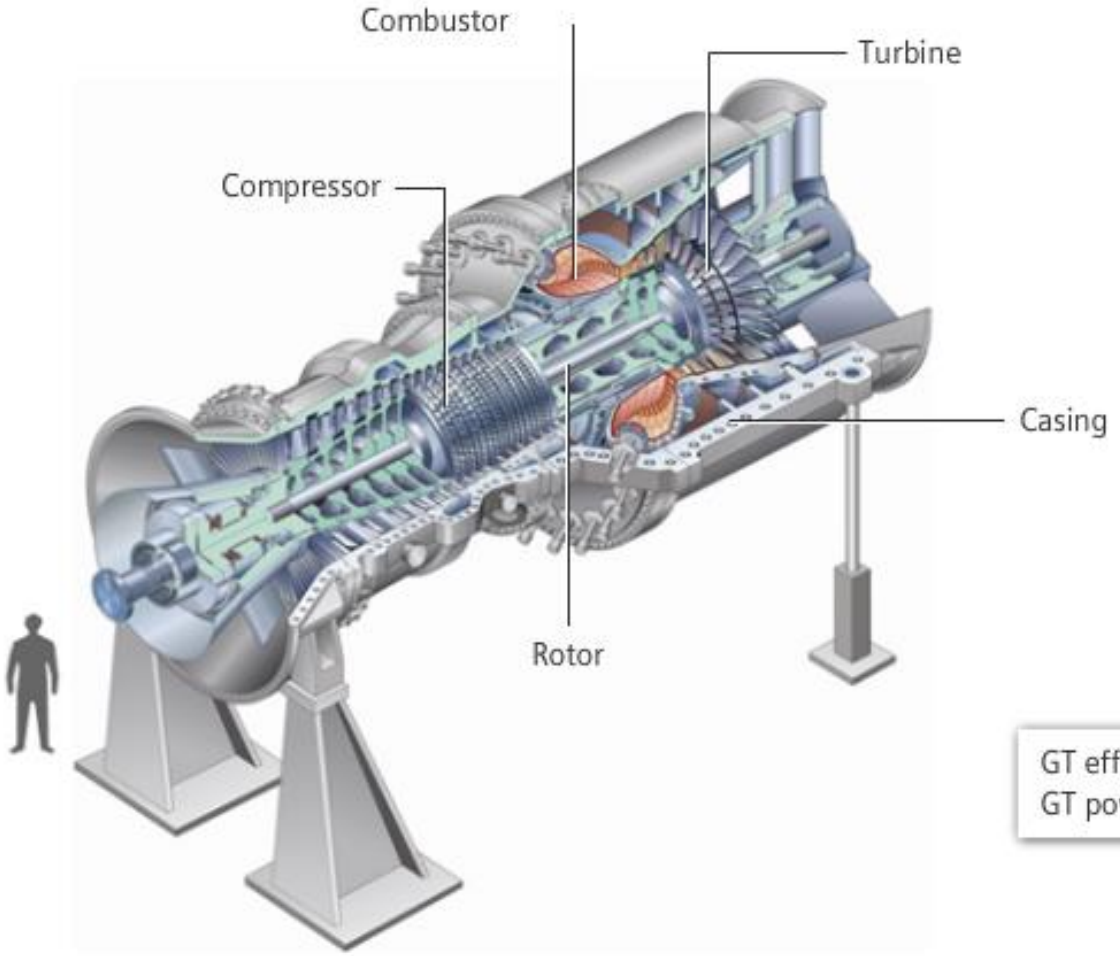
Correct

Well done, these are the right answers!

Structure of a 4000F



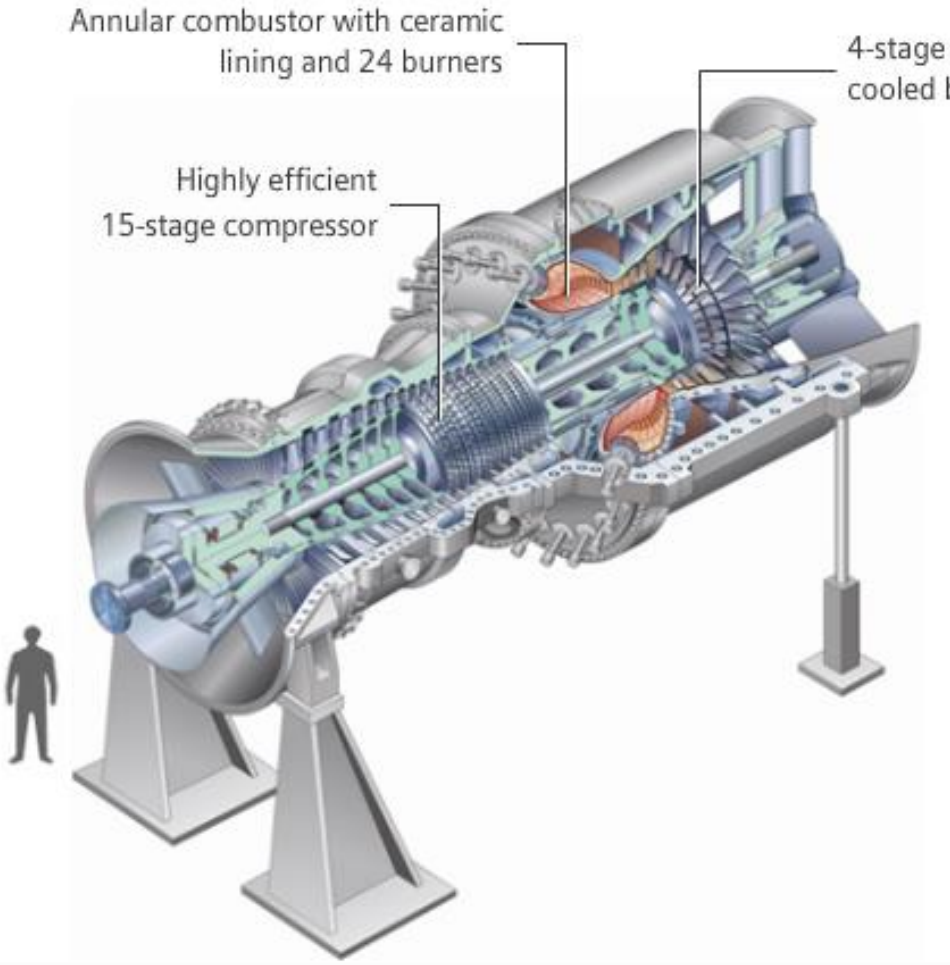
Structure of a 4000F



GT efficiency of nearly 40 %
GT power of up to 295 MW*

*) according to ISO 2314

Structure of a 4000F



GT efficiency of nearly 40 %
GT power of up to 295 MW*

*) according to ISO 2314

PopQuiz #05

- ○ 4 burners
- ○ 15 burners
- ○ 24 burners
- ○ 36 burners
- ○ 40 burners

How many burners does an SGT5-4000F have?

Evaluate

PopQuiz #05

How many burners does an SGT5-4000F have?

- ○ 4 burners
- ○ 15 burners
- ◉ 24 burners
- ○ 36 burners
- ○ 40 burners

Correct

Very good, this is the correct answer!

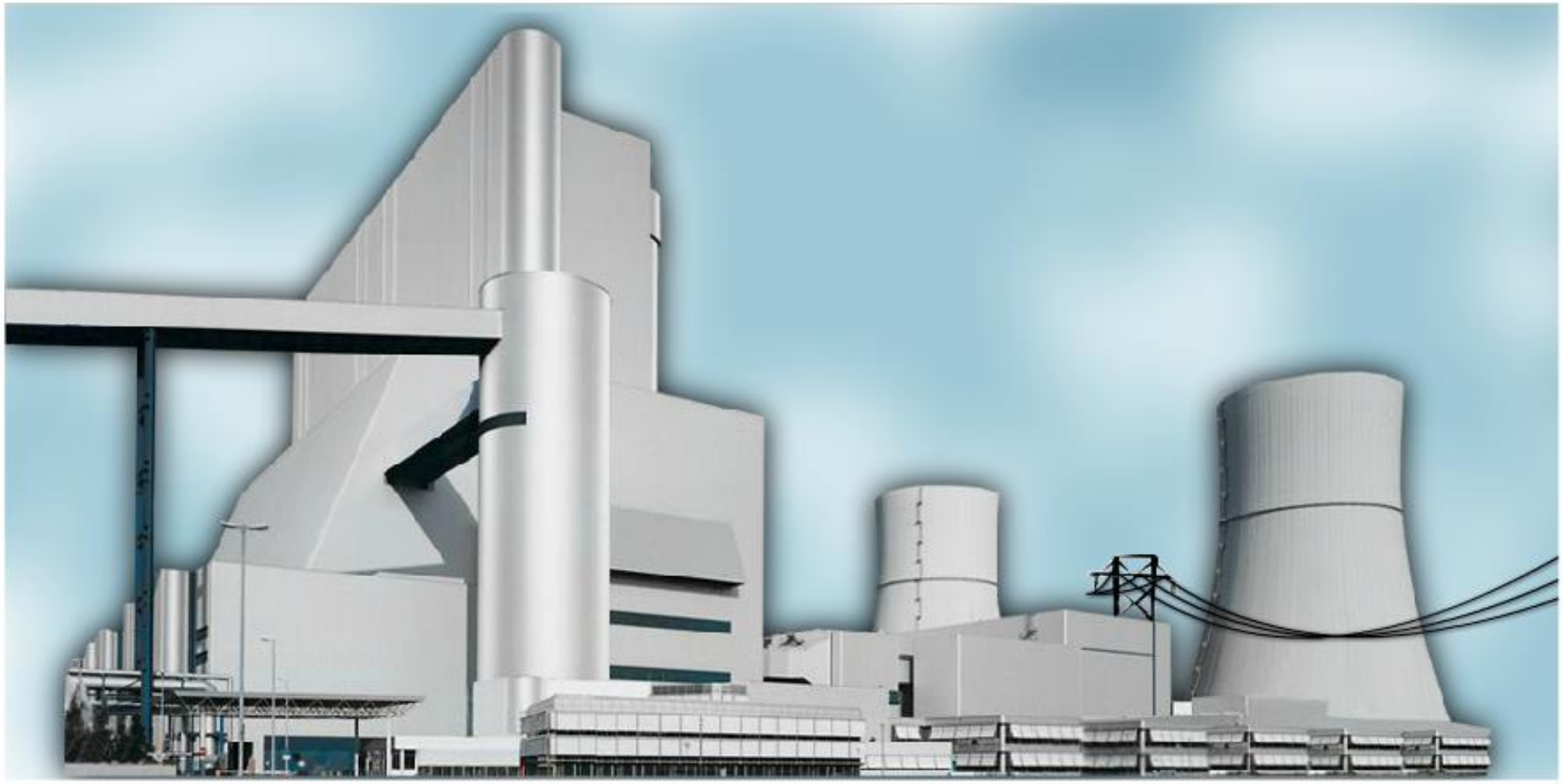
SIEMENS

Section:05

Fosil Power Generation and Steam Turbines

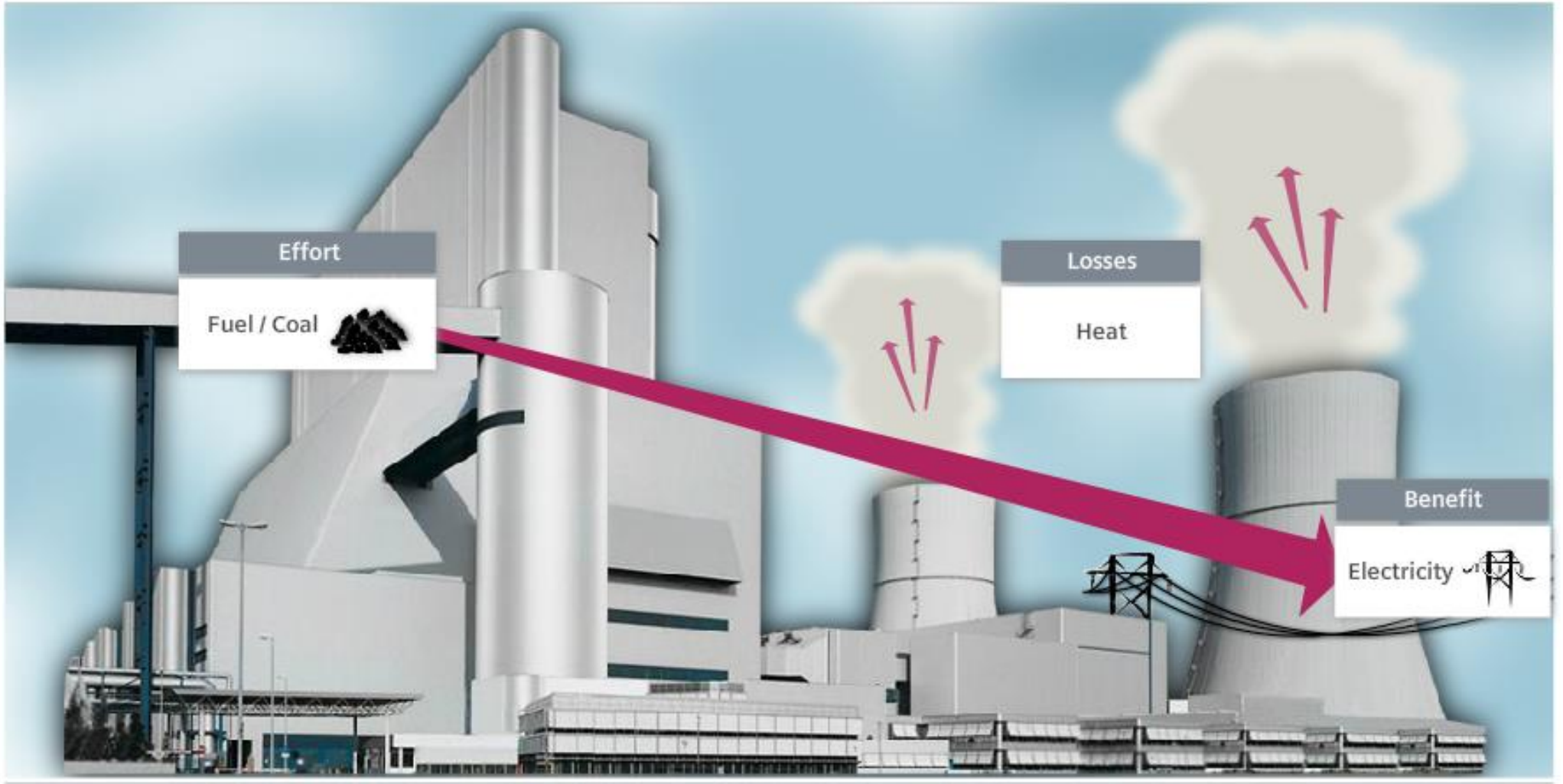
Steam Turbine Basics

Power Plant Process

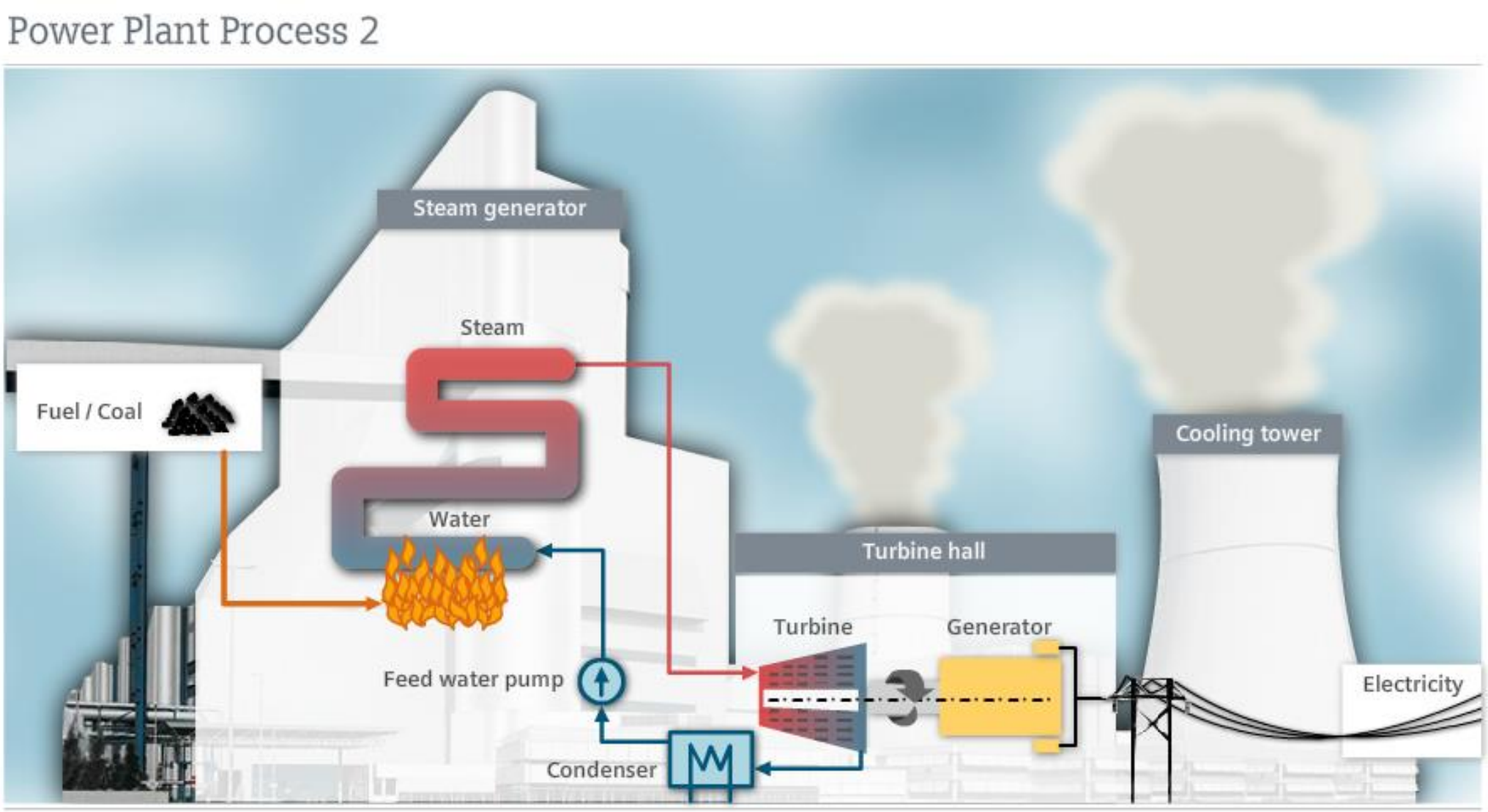


Steam Turbine Basics

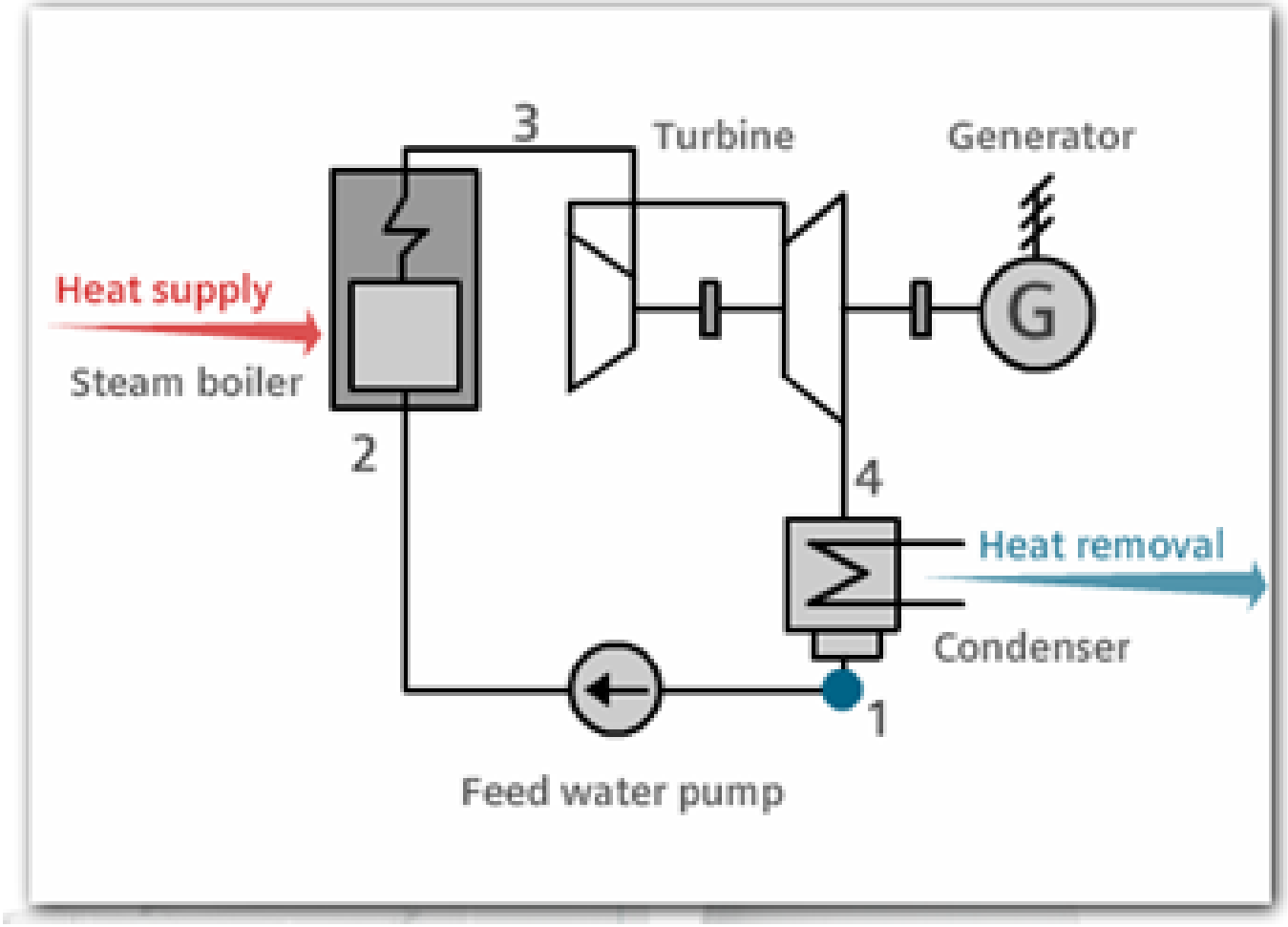
Power Plant Process



Steam Turbine Basics

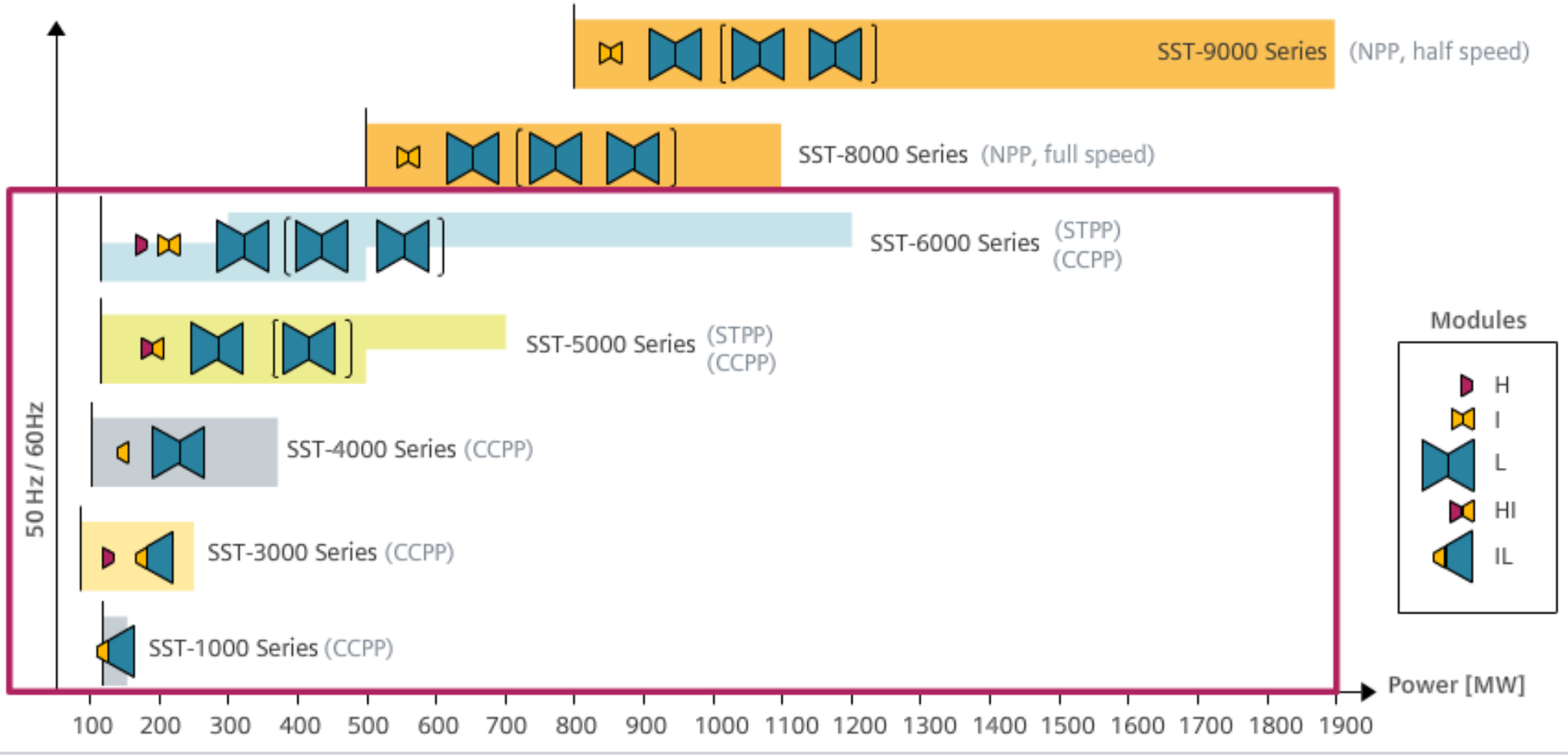


Steam Turbine Basics



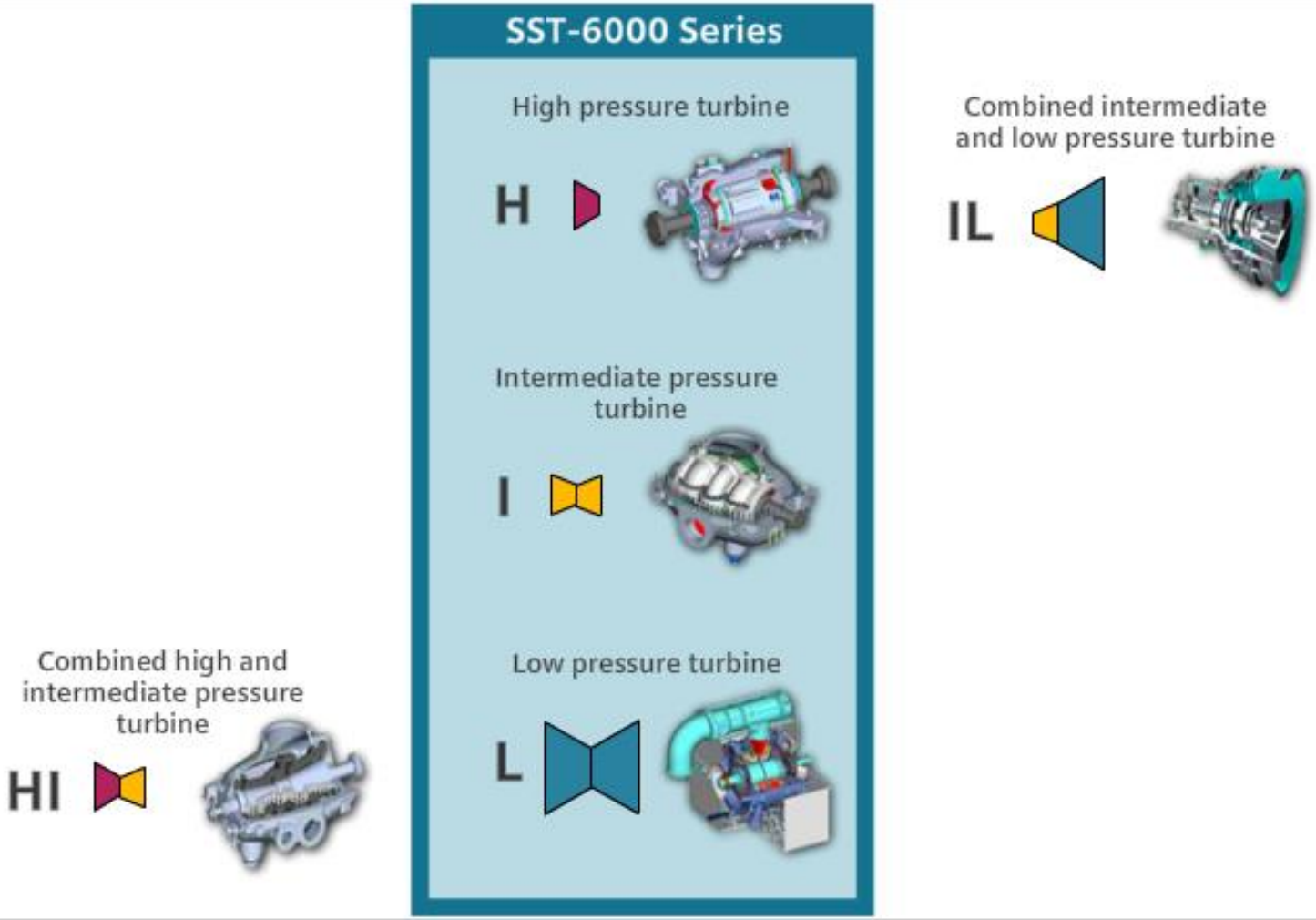
Steam Turbine Basics

All Power Range Applications for Steam Turbine Series



Steam Turbine Basics

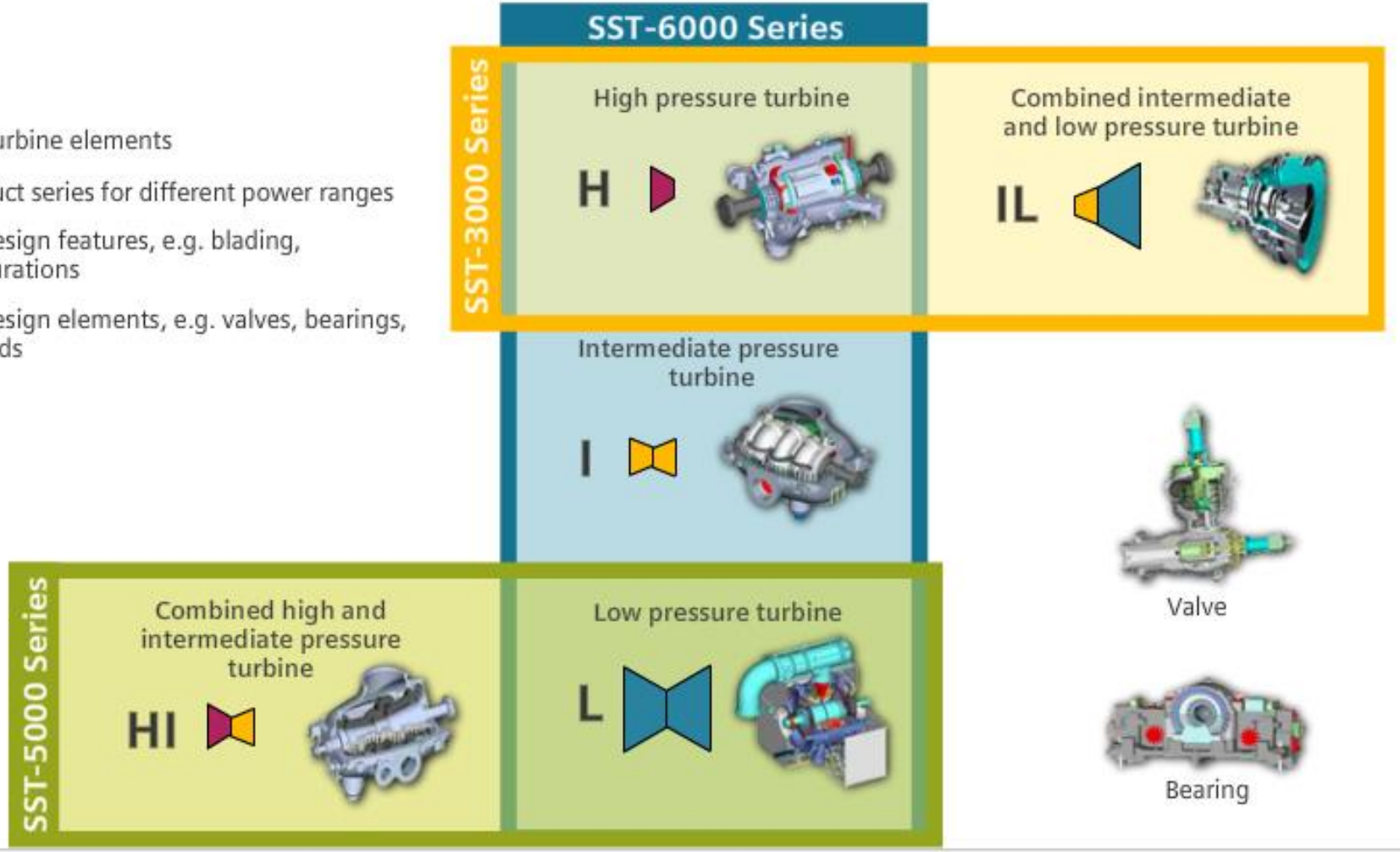
Modular Concept of the Product Series



Steam Turbine Basics

Modular Concept of the Product Series

- Five basic turbine elements
- Three product series for different power ranges
- Common design features, e.g. blading, seal configurations
- Common design elements, e.g. valves, bearings, auxiliary skids



Steam Turbine Basics

Product Series

SST-3000 Series

90 MW – 250 MW

SST-5000 Series

120 MW – 700 MW

SST-6000 Series

300 MW – 1200 MW

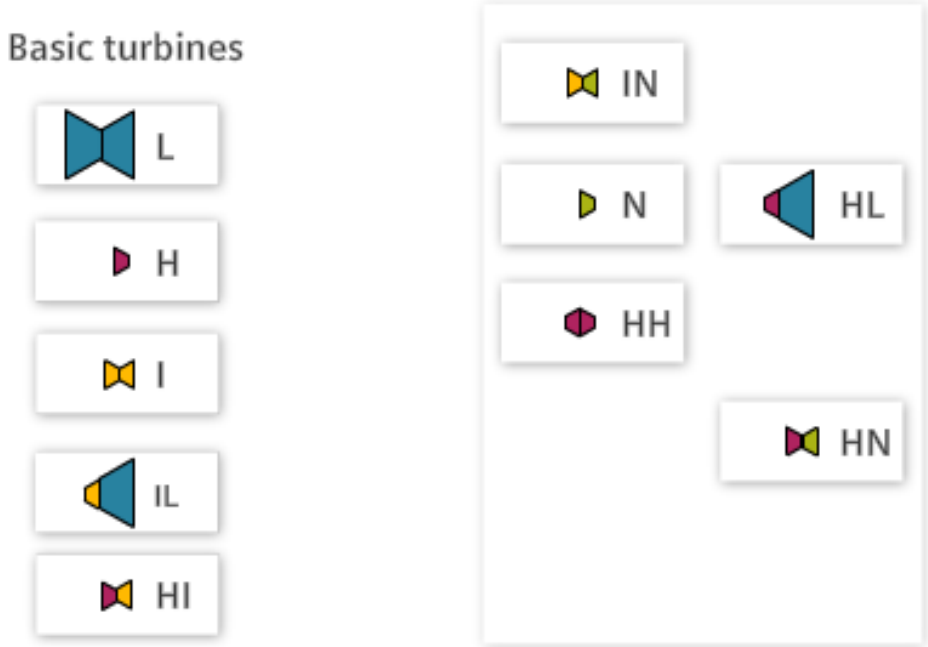
PopQuiz #06

Basic turbines

Which are the basic turbines?

PopQuiz #06

Which are the basic turbines?

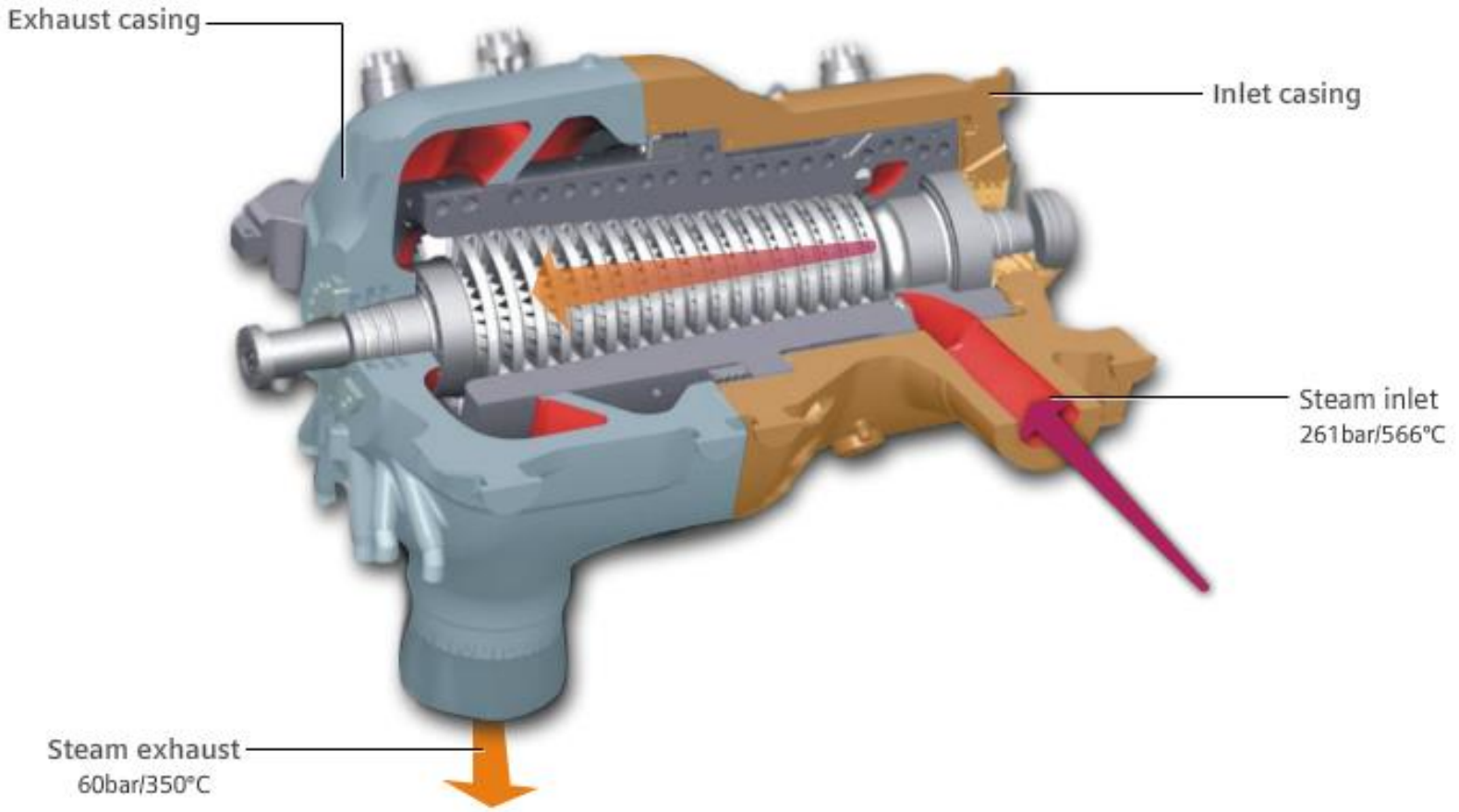


Correct

You have been paying attention! Those are the correct answers.

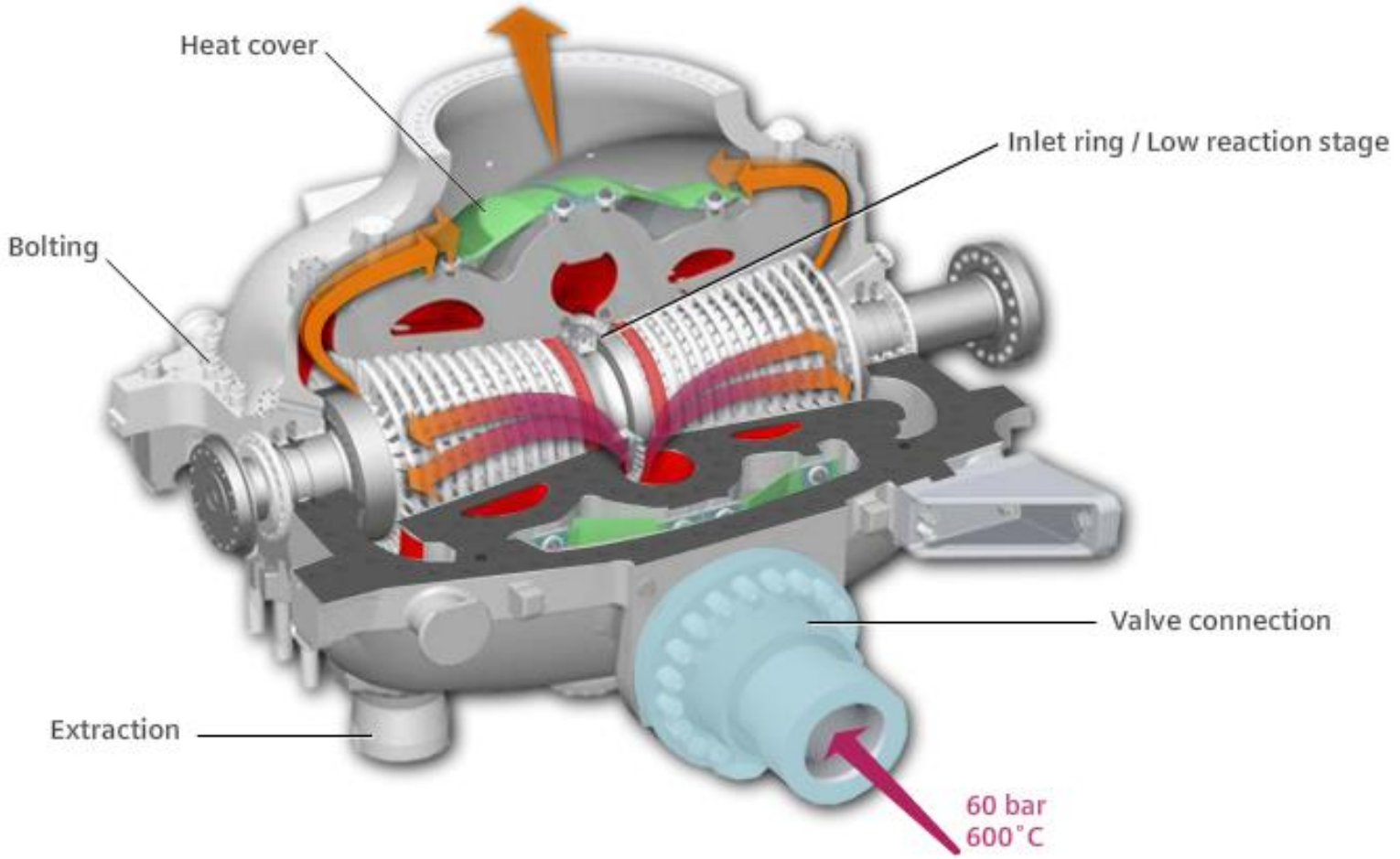
Steam Turbine Basics

Components – High Pressure Turbine



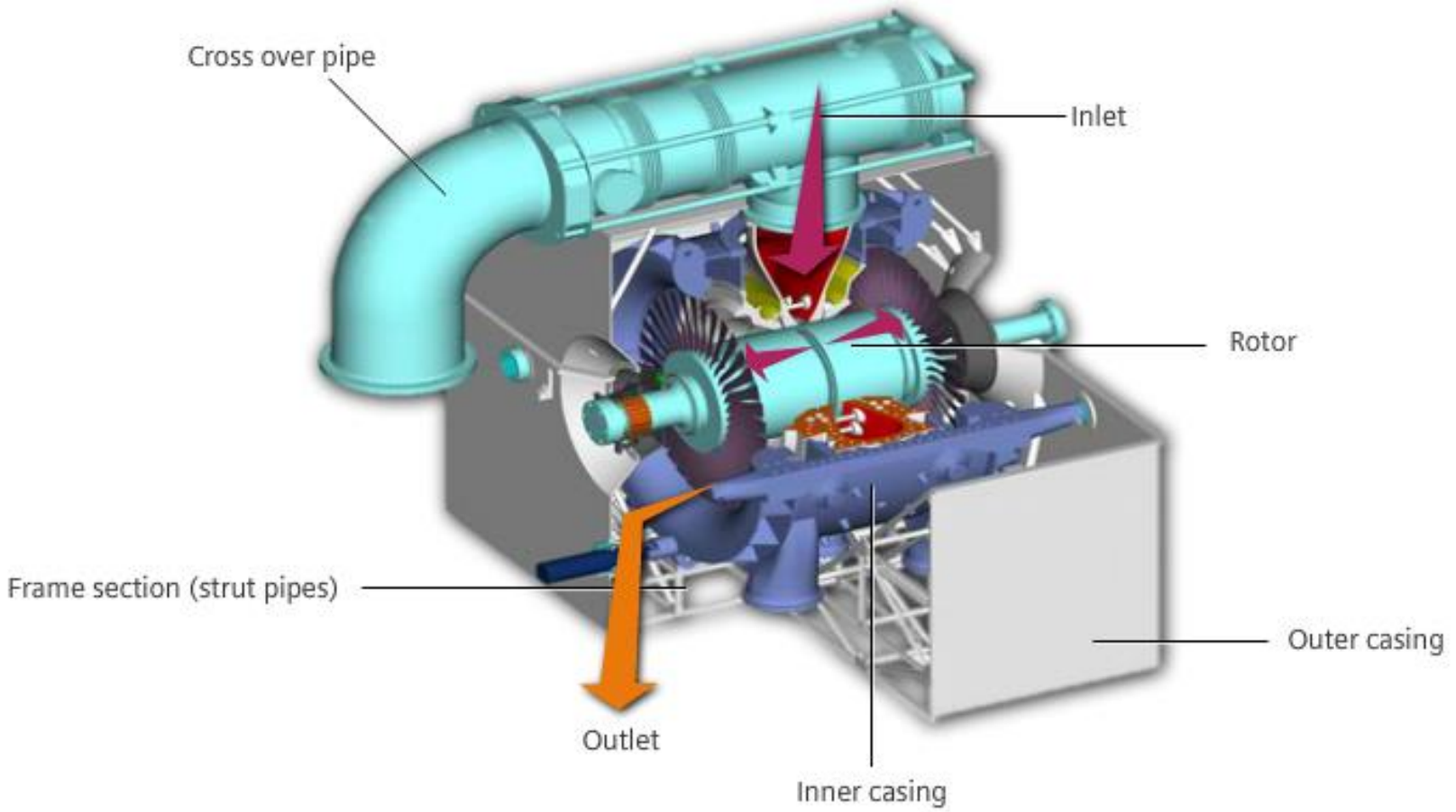
Steam Turbine Basics

Intermediate Pressure Turbine – Components



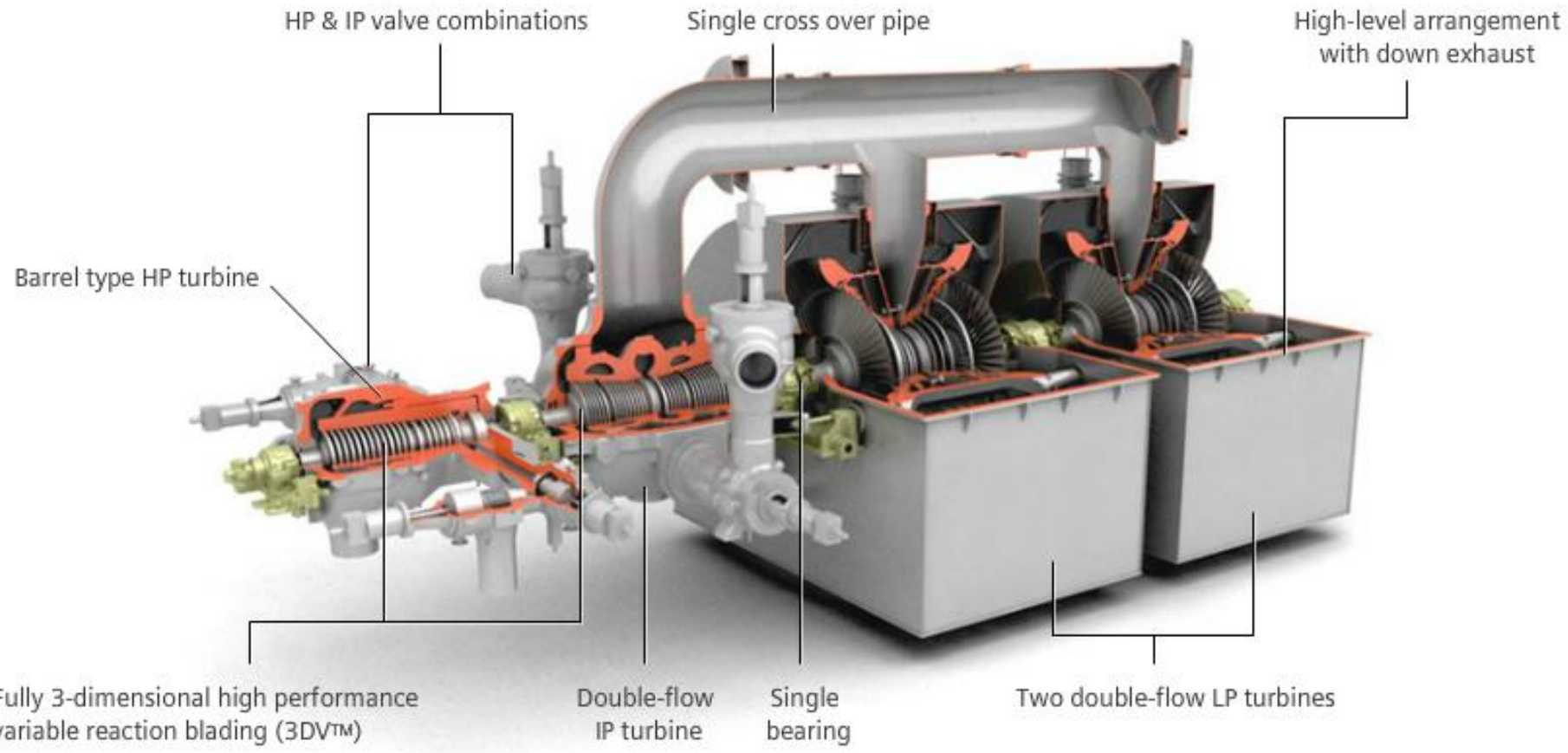
Steam Turbine Basics

Low Pressure Turbine



Steam Turbine Basics

Turboset – SST-6000 Product Series



Steam Turbine Basics

Basic Information 2 – Mollier Diagram (Process Visualization)

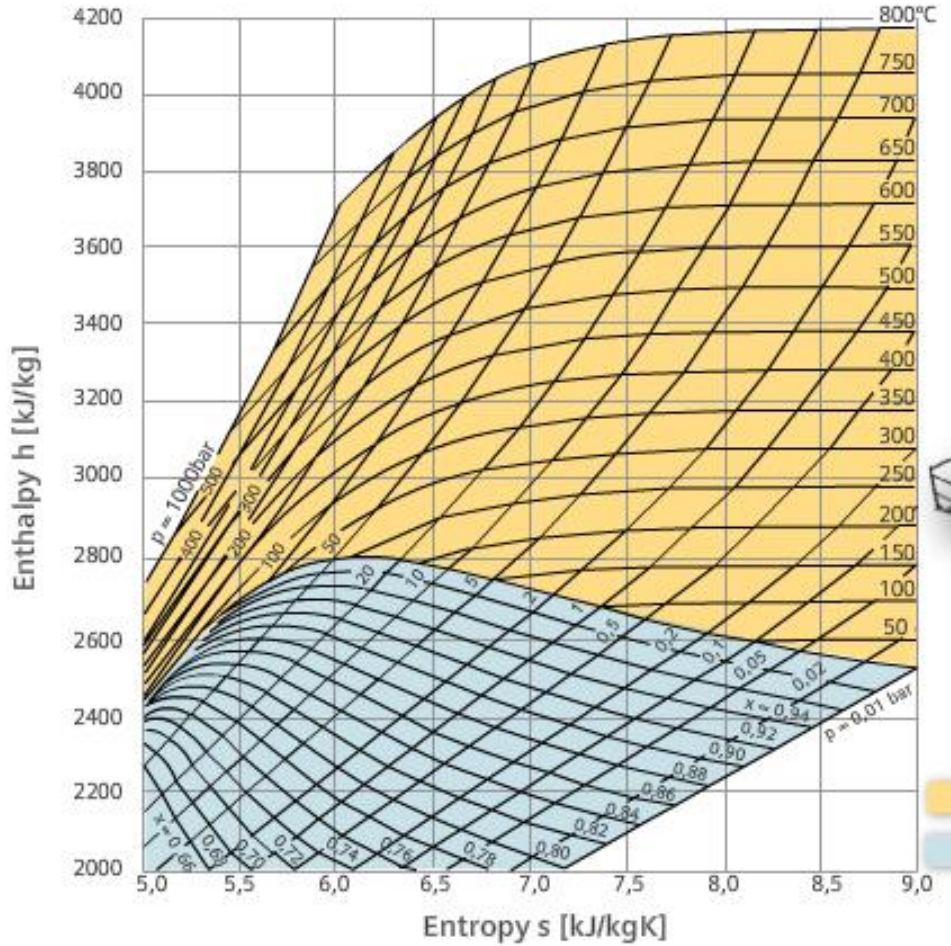
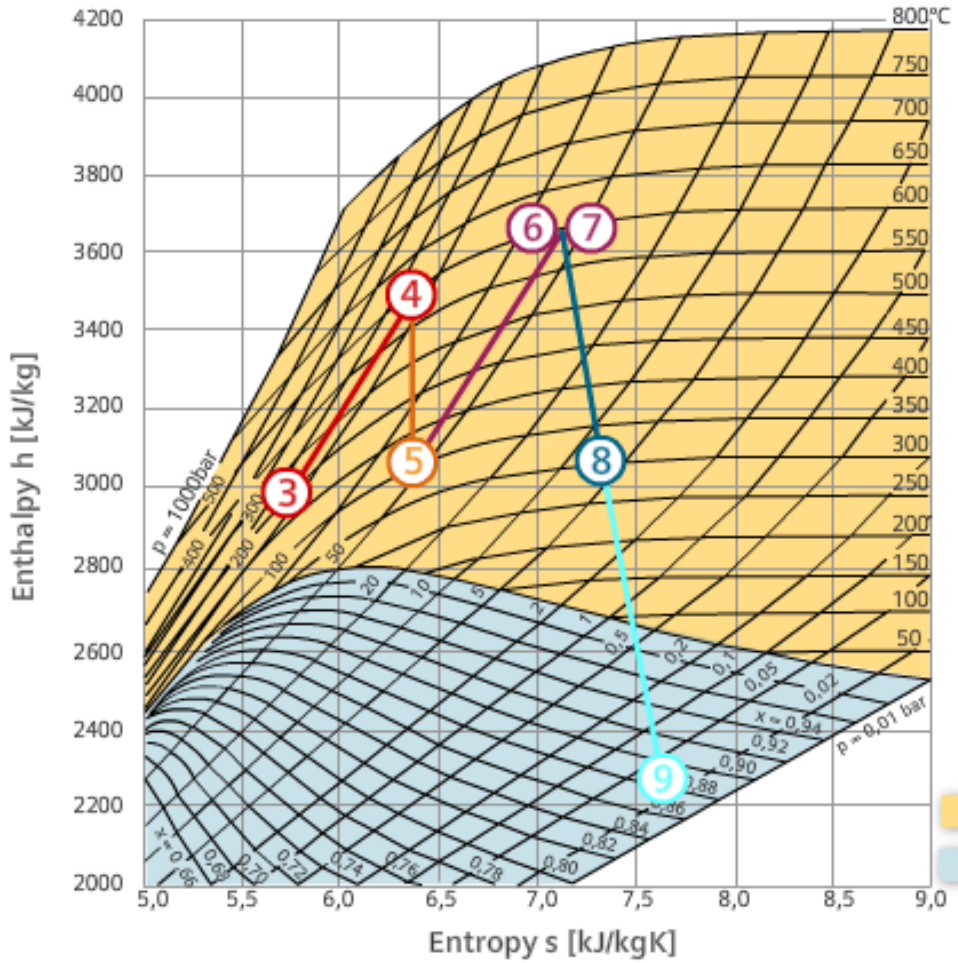


Diagram area 100% steam (superheated)

Diagram area steam / water mixture (wet steam region)

Steam Turbine Basics

Basic Information 2 – Mollier Diagram (Process Visualization)



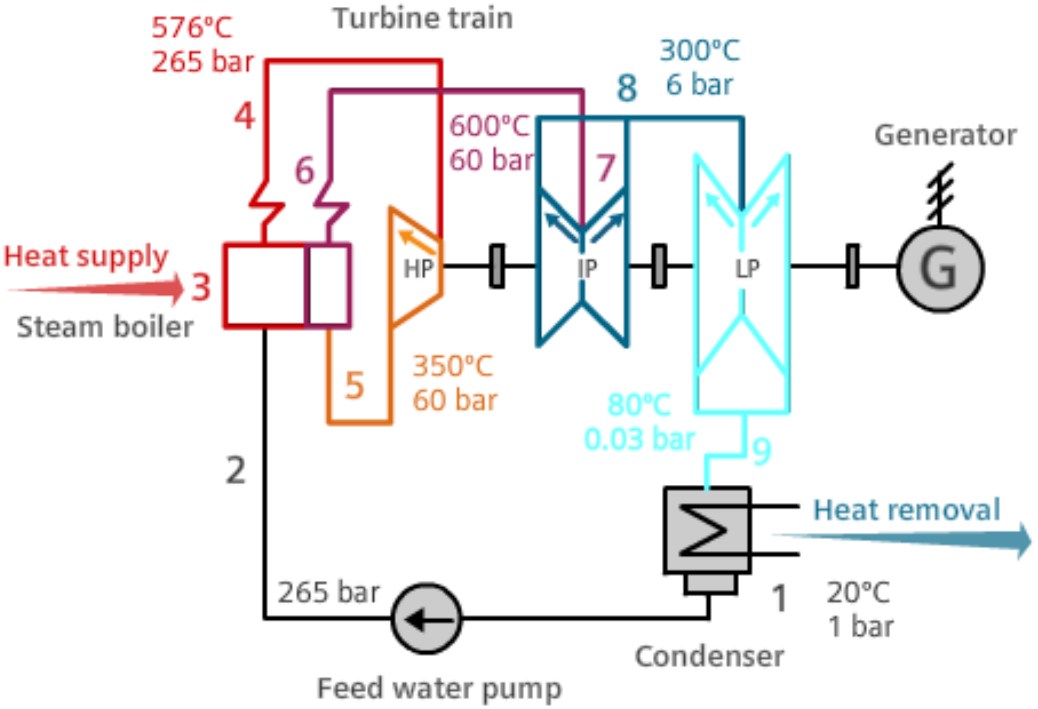
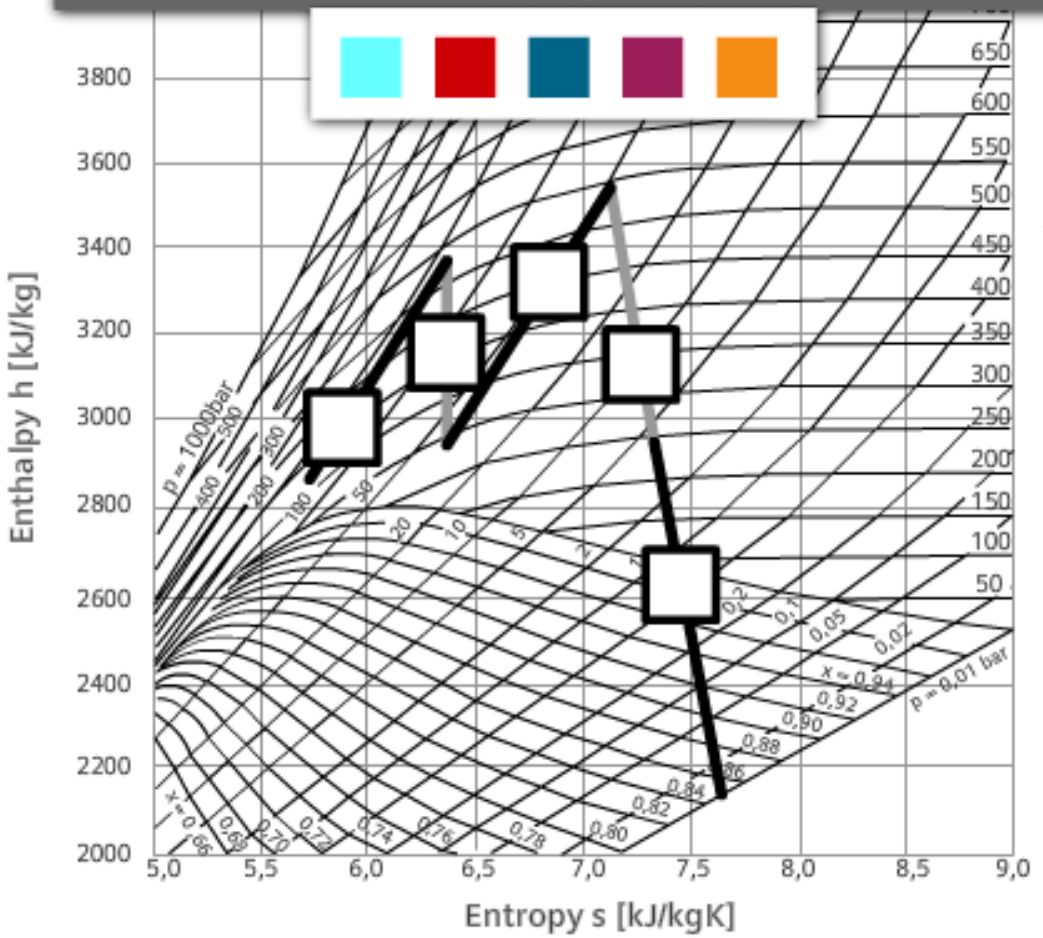


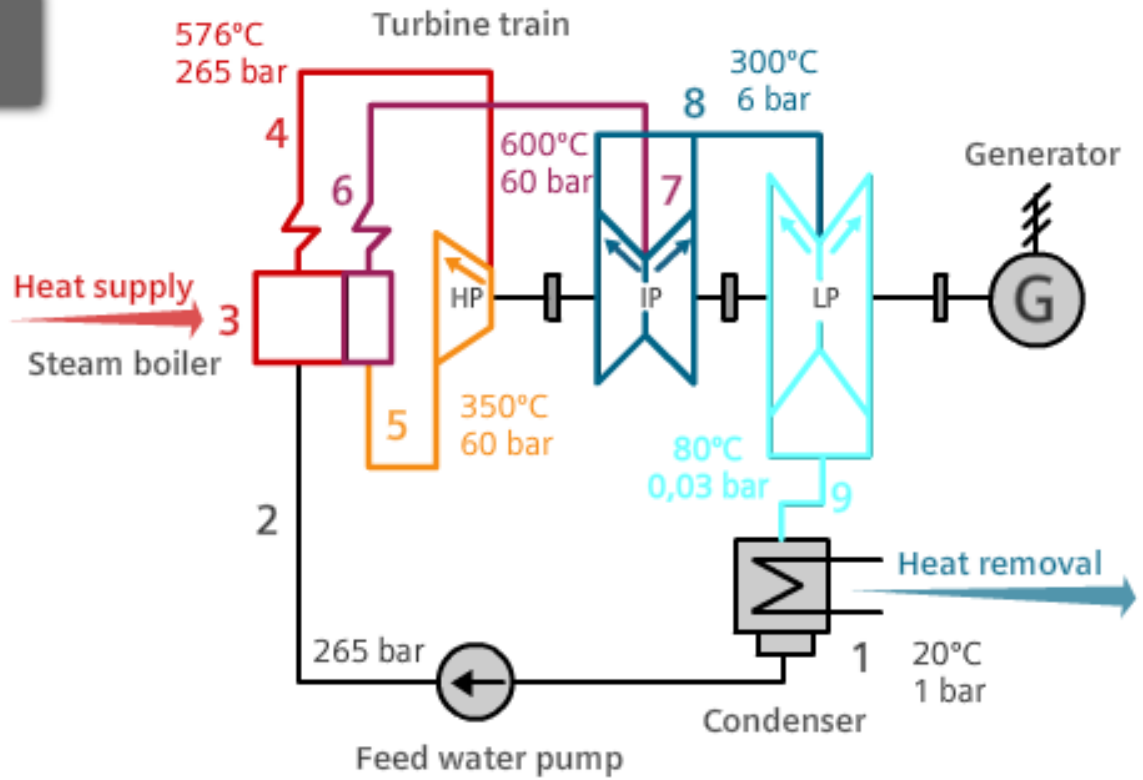
Diagram area 100% steam (superheated)

Diagram area steam / water mixture (wet steam region)

PopQuiz #07

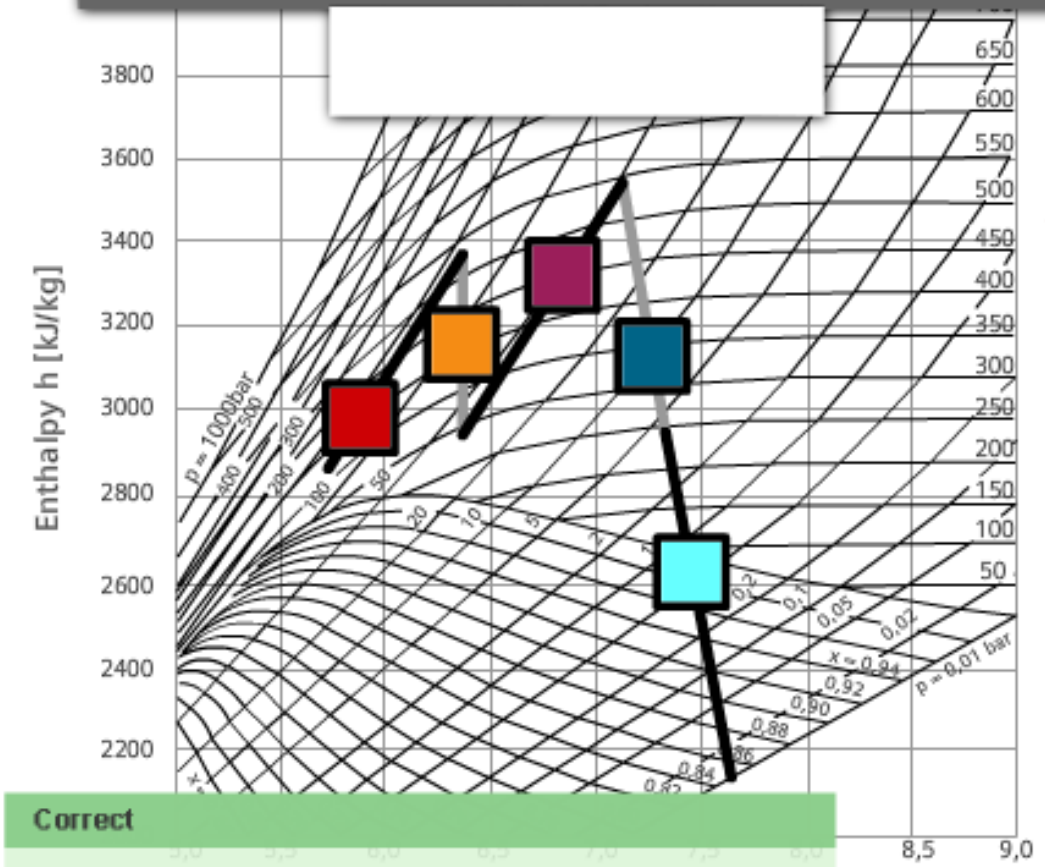
Please assign the correct colors to the lines in the Moiller enthalpy-entropy diagram.





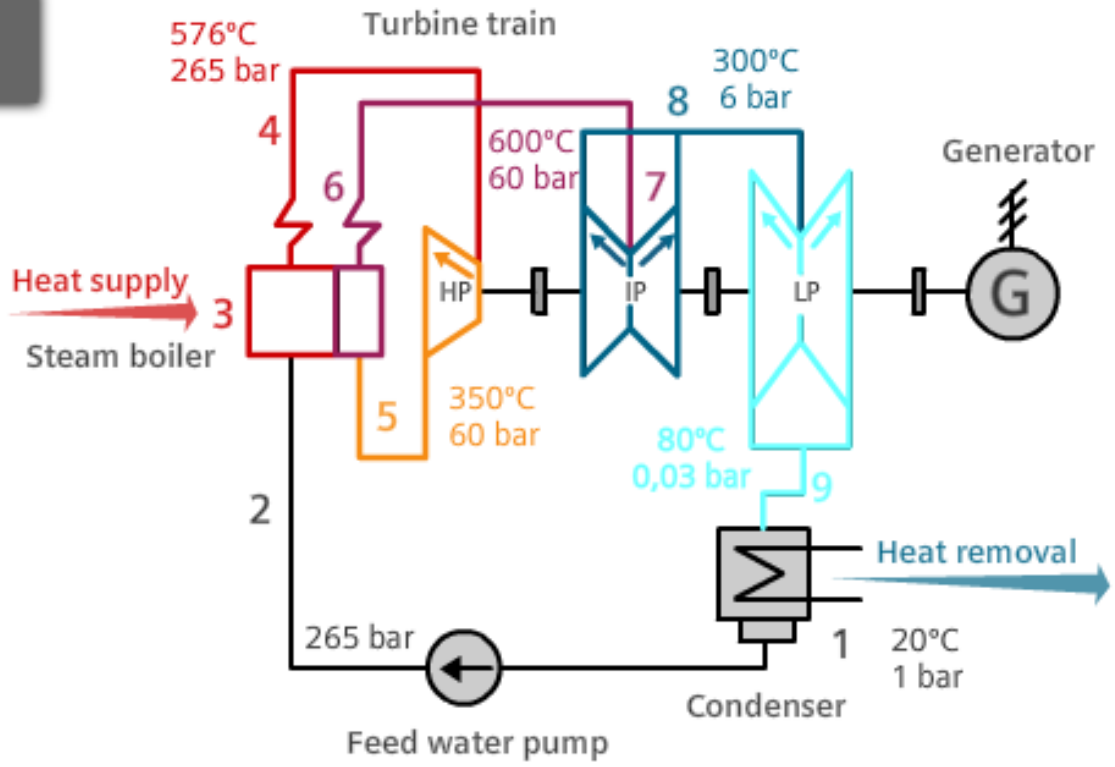
PopQuiz #07

Please assign the correct colors to the lines in the Moiller enthalpy-entropy diagram.



Correct

You have been paying attention! Those are the correct answers.



PopQuiz #08

- ○ 576°C
- ○ 756°C
- ○ 675°C

Which temperature is reached by the steam in the combustion plant in our example?

PopQuiz #08

- (●) 576°C
- ( ) 756°C
- ( ) 675°C

Correct

You have been paying attention! This is the correct answer.

Which temperature is reached by the steam in the combustion plant in our example?

PopQuiz #09

- ○ 6 hectopascals
- ○ 16 bar
- ○ 6 bar
- ○ 10 at

What is the pressure of the steam when it is admitted to the low-pressure turbine?

PopQuiz #09

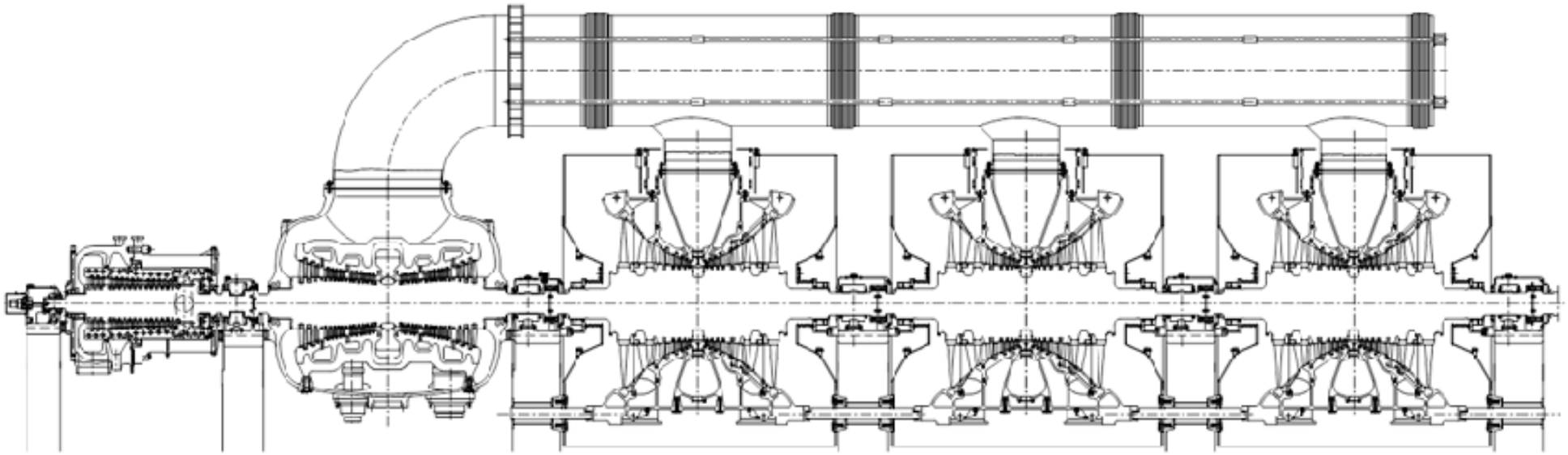
What is the pressure of the steam when it is admitted to the low-pressure turbine?

- ○ 6 hectopascals
- ○ 16 bar
- ◉ 6 bar
- ○ 10 at

Correct

Well done! That is the correct answer.

SST-6000 Series – Low Pressure Turbine



PopQuiz #10

- ○ The steam volume increases.
- ○ The steam volume decreases.
- ○ The steam volume stays the same.

Does the steam volume increase or decrease as it flows through the turbines?

PopQuiz #10

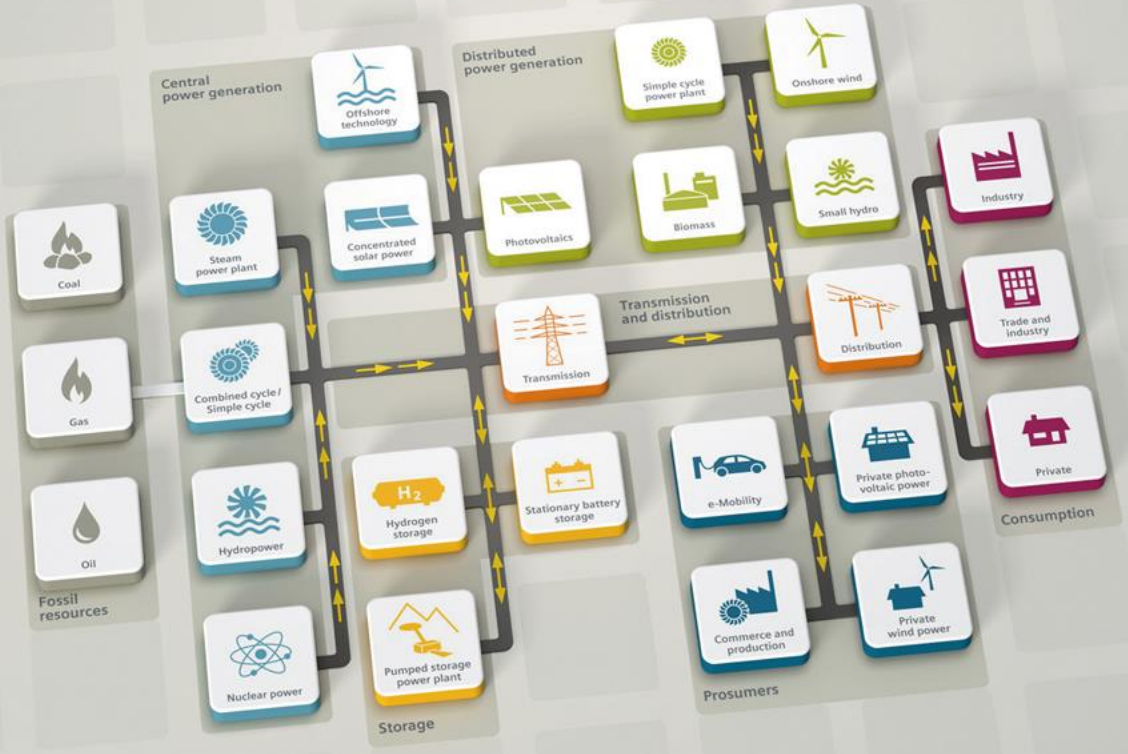
- (●) The steam volume increases.
- ( ) The steam volume decreases.
- ( ) The steam volume stays the same.

Correct

Well done!

Does the steam volume increase or decrease as it flows through the turbines?

SIEMENS



Suha ISIKLI says:

Thank You ;-)