R&D activities on sCO_2 in Europe

sCO_2 cycles for Nuclear Power Production

Seventh episode – 30 September 2024

This webinar is in cooperation with 9 European R&D projects

COMPASsCO_2

SCARABEUS

iSOP

$CO_2OLHEAT$

sCO_2-4-NPP

CARBOSOLA

DESOLINATION

SOLAR sCO_2OL

sCO_2-Efekt

Webinar content & speakers

- **Nuclear landscape, a brief introduction**
  (Moderator Albannie Cagnac – EDF)

- **Use of carbon dioxide in nuclear energy**
  (Otakar Frýbort – Research Centre Řež)

- **sCO_2 for molten salt reactors**
  (Paul Levisse – NAAREA)

- **Fusion Energy and the role of sCO_2**
  (Jack Acres – UK Atomic Energy Authority)

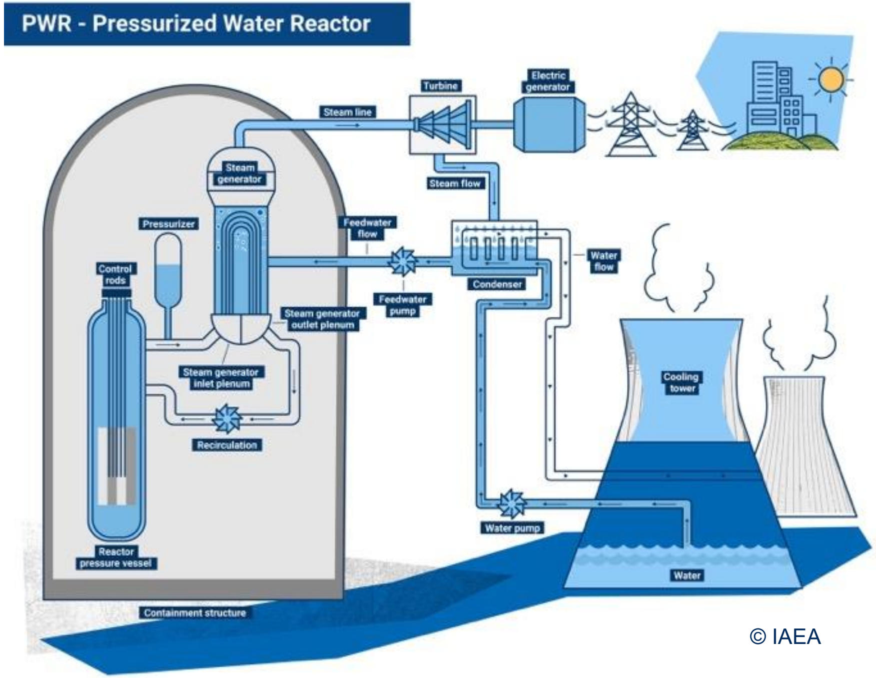
What is the first word that comes to your mind when thinking about Nuclear Power Generation?

Baseload Power
Decarbonisation
Carbon emissions free
Decarbonation
SCO2 Power Conversion
Fision
Sco2
Zero Emissions
Slow
Low Carbon
Heavily regulated
high risk
Expensive
Safety
Nuclear waste
Cheap
Promising
SMR
Waste
Scories
Innovation
Dangerous
Clean energy
Stable
Efficiency
Capital cost
Power cycle
Clean
CO2 free
Useful
Resurfacing
Future
Special project
Steam turbine
Edficiency
Closed cycle
Low C02
Radioaktive Wasser issue
Baseload
Cheap reliable
Dangerous waste

Nuclear landscape, a brief introduction

Albannie Cagnac, EDF

Nuclear Energy ?



© IAEA

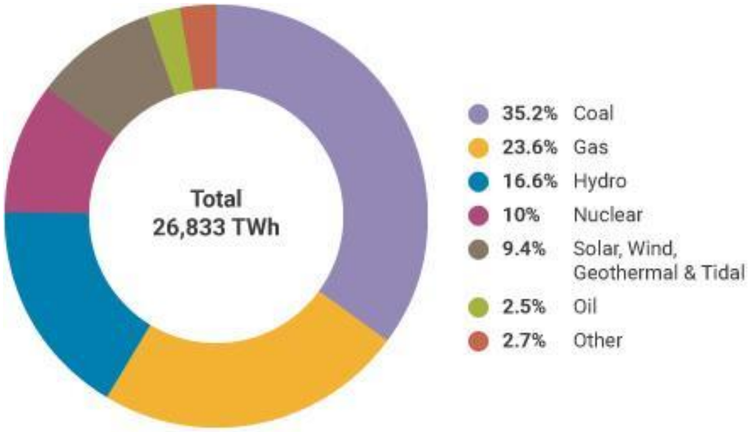
Nuclear plants vs Coal & Gas plants

Nuclear power plants use nuclear fission (and one day nuclear fusion) to produce electricity while thermal power plants use the heat from burning coal or gas to produce electricity.

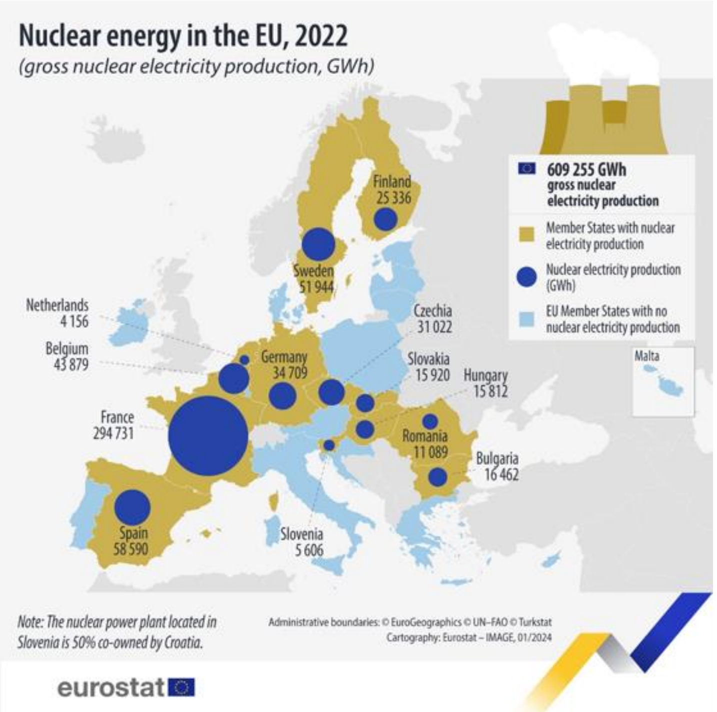
Both need turbine, condenser, cooling system, heat exchangers.

Nuclear Energy in the world

Worldwide Production



Source: IEA



Nuclear energy in the EU, 2022

(gross nuclear electricity production, GWh)

Note: The nuclear power plant located in Slovenia is 50% co-owned by Croatia.

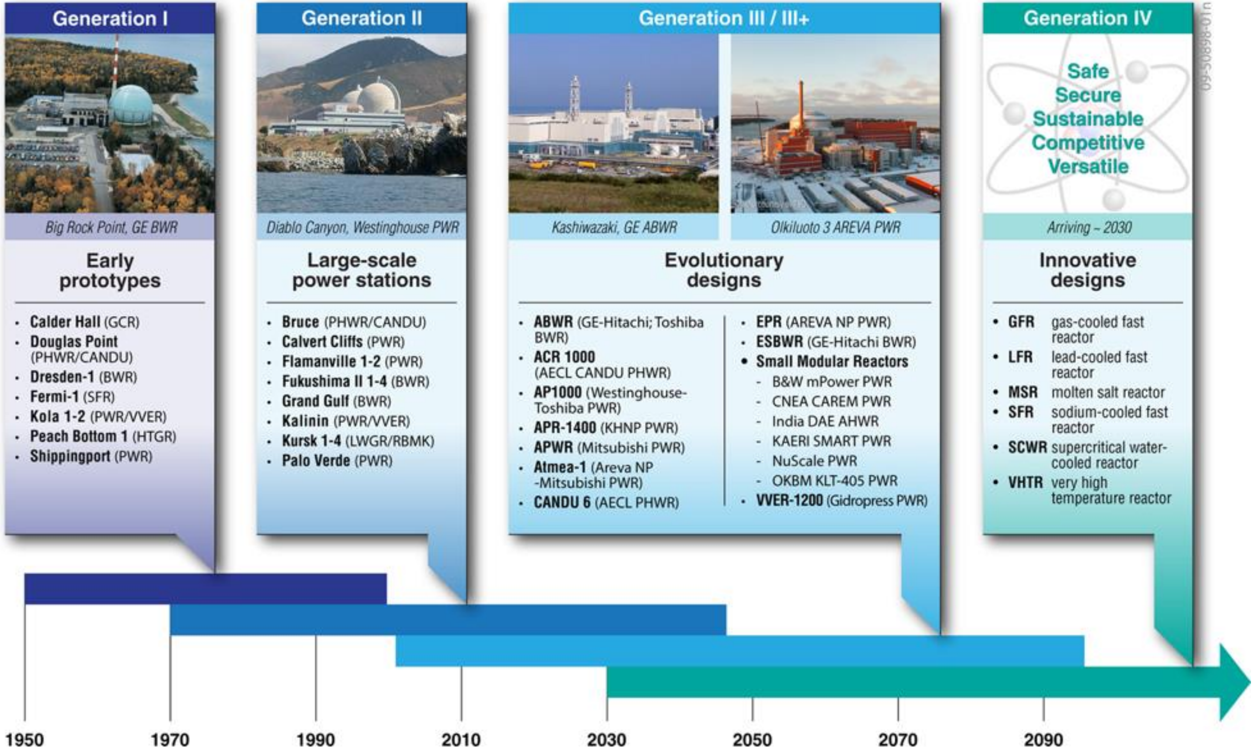
Administrative boundaries: © EuroGeographics © UN–FAO © Turkstat
Cartography: Eurostat – IMAGE, 01/2024

eurostat

Around 22% of the total electricity produced in the EU

Nuclear Technology?

Technology evolving with scientific and engineering advances.



Generation I

Big Rock Point, GE BWR

Early prototypes

- **Calder Hall** (GCR)
- **Douglas Point** (PHWR/CANDU)
- **Dresden-1** (BWR)
- **Fermi-1** (SFR)
- **Kola 1-2** (PWR/VVER)
- **Peach Bottom 1** (HTGR)
- **Shippingport** (PWR)

Generation II

Diablo Canyon, Westinghouse PWR

Large-scale power stations

- **Bruce** (PHWR/CANDU)
- **Calvert Cliffs** (PWR)
- **Flamanville 1-2** (PWR)
- **Fukushima II 1-4** (BWR)
- **Grand Gulf** (BWR)
- **Kalinin** (PWR/VVER)
- **Kursk 1-4** (LWGR/RBMK)
- **Palo Verde** (PWR)

Generation III / III+

Kashiwazaki, GE ABWR

Olkiluoto 3 AREVA PWR

Evolutionary designs

- **ABWR** (GE-Hitachi; Toshiba BWR)
- **ACR 1000** (AECL CANDU PHWR)
- **AP1000** (Westinghouse-Toshiba PWR)
- **APR-1400** (KHNP PWR)
- **APWR** (Mitsubishi PWR)
- **Atmea-1** (Areva NP -Mitsubishi PWR)
- **CANDU 6** (AECL PHWR)
- **EPR** (AREVA NP PWR)
- **ESBWR** (GE-Hitachi BWR)
- **Small Modular Reactors**
  - B&W mPower PWR
  - CNEA CAREM PWR
  - India DAE AHWR
  - KAERI SMART PWR
  - NuScale PWR
  - OKBM KLT-405 PWR
- **VVER-1200** (Gidropress PWR)

Generation IV

Safe
Secure
Sustainable
Competitive
Versatile

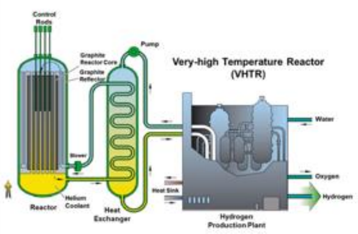
Arriving ~ 2030

Innovative designs

GFR	gas-cooled fast reactor
LFR	lead-cooled fast reactor
MSR	molten salt reactor
SFR	sodium-cooled fast reactor
SCWR	supercritical water-cooled reactor
VHTR	very high temperature reactor

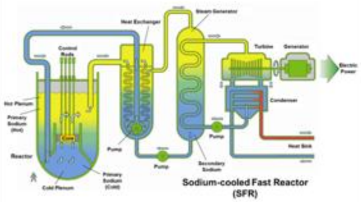
Next generation : Generation IV concepts

First researches for sCO2 use in nuclear : 1960's / 1970's



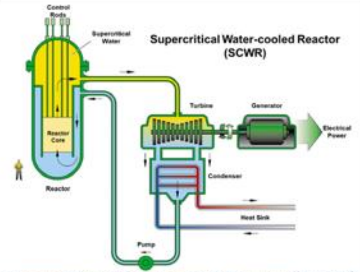
Very-high Temperature Reactor (VHTR)

Neutron spectrum: Thermal neutron
Coolant: Helium
Outlet temperature: 900 to 1,000°C
Fuel cycle: Open
Output power: 250 to 300 MWe



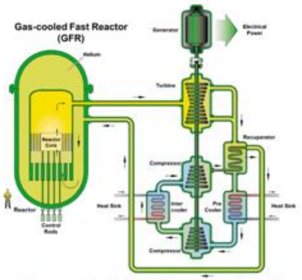
Sodium-cooled Fast Reactor (SFR)

Neutron spectrum: High-speed neutron
Coolant: Sodium
Outlet temperature: 500 to 550°C
Fuel cycle: Closed
Output power: 50 to 1,500 MWe



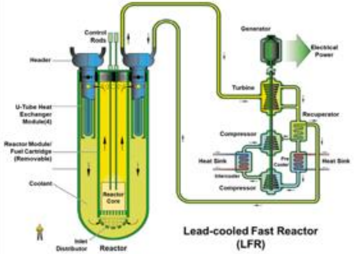
Supercritical Water-cooled Reactor (SCWR)

Neutron spectrum: Thermal neutron or
High-speed neutron
Coolant: Water
Outlet temperature: 510 to 625°C
Fuel cycle: Open or Closed
Output power: 300 to 1,500 MWe



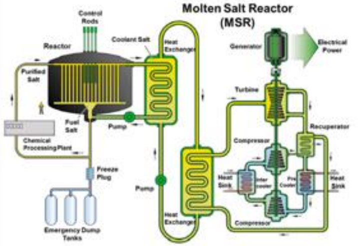
Gas-cooled Fast Reactor (GFR)

Neutron spectrum: High-speed neutron
Coolant: Helium
Outlet temperature: 850°C
Fuel cycle: Closed
Output power: 1,200 MWe



Lead-cooled Fast Reactor (LFR)

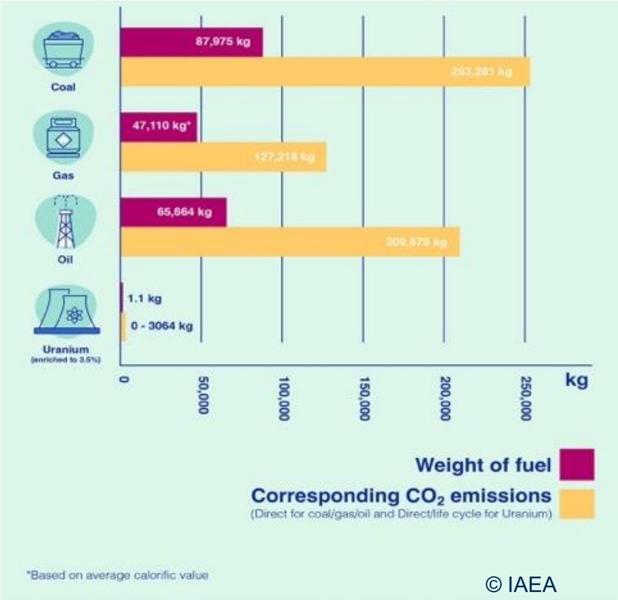
Neutron spectrum: High-speed neutron
Coolant: Lead
Outlet temperature: 80 to 570°C
Fuel cycle: Closed
Output power: 20 to 1,200 MWe



Molten Salt Reactor (MSR)

Neutron spectrum: Thermal neutron or
High-speed neutron
Coolant: Fluoride salt or Chloride salt
Outlet temperature: 700 to 800°C
Fuel cycle: Open or Closed
Output power: 1,000 MWe

Reviving interest in nuclear potential for global transition



*Based on average calorific value

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Low emission energy

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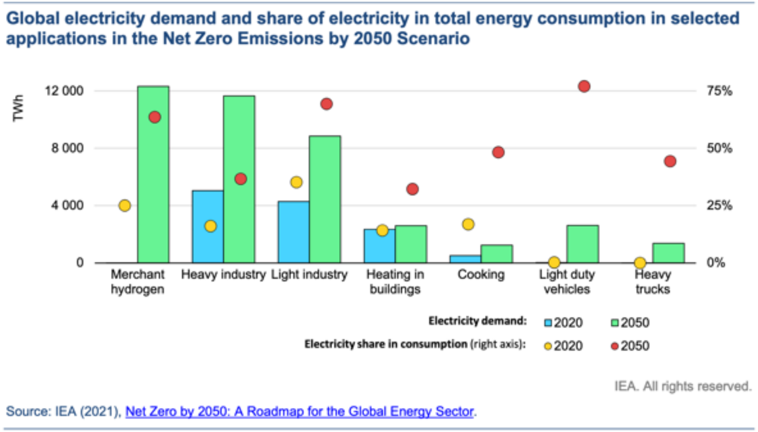
Increasing demand



Global electricity demand and share of electricity in total energy consumption in selected applications in the Net Zero Emissions by 2050 Scenario

IEA. All rights reserved.

Source: IEA (2021), Net Zero by 2050: A Roadmap for the Global Energy Sector.

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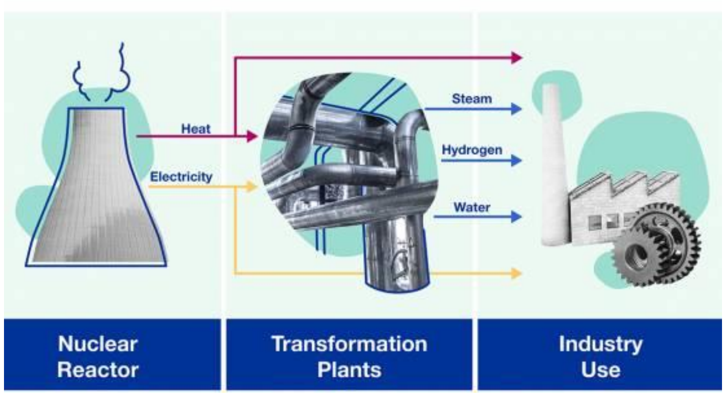
Yes! In fact, combined with renewables, like solar or wind energy, nuclear energy offers **reliability, flexibility and very low emissions.**

Reviving interest in nuclear’s potential

New non electric applications



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District heating

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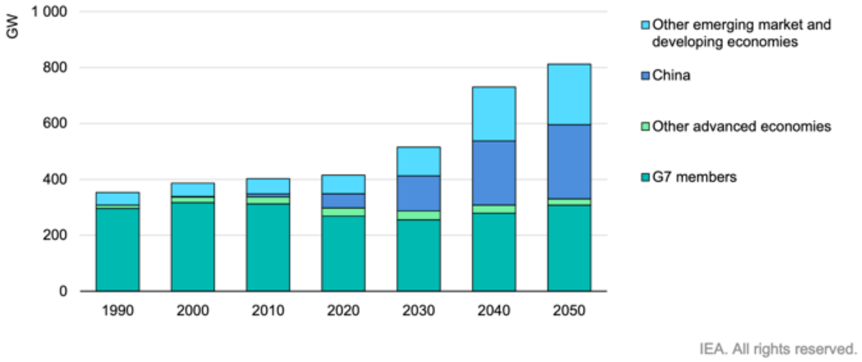
Desalination

Increased power capacity to reach net zero targets

Nuclear power capacity by country/region in the Net Zero Emissions by 2050 Scenario



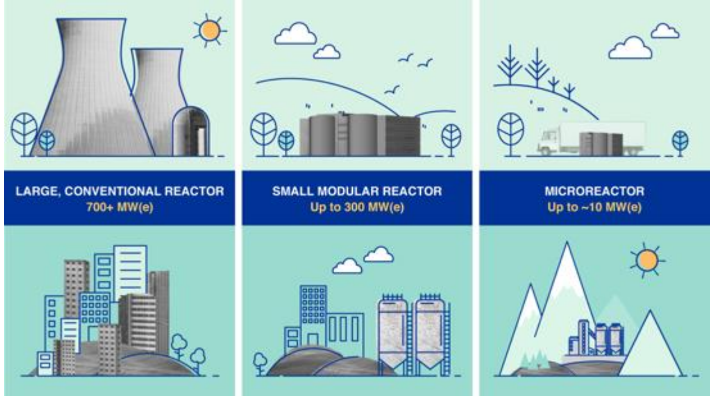
Note: Power capacity refers to gross capacity, before accounting for onsite electricity consumption.

Sources: IEA (2021), Net Zero by 2050: A Roadmap for the Global Energy Sector; IEA (2021), Achieving Net Zero Electricity Sectors in G7 Members.

NEW R&D PROGRAMS or CONSTRUCTIONS (USA, FR, UK, PO, CZ, CA, PRC, INDIA…)

New Challenges for competitiveness

New designs : SMRs



- **Small** – fraction of the size of a conventional NPP
- **Modular –** factory-assembled and transported as a unit to a location for installation.
- **Reactors –** to generate heat to produce energy.

Challenges

Technological innovations (efficiency, safety)

Cost-competitiveness

Policy and regulatory

Safety and waste management

The advantages of sCO2 cycles, already discussed in previous episodes, make them a good choice for these new reactors.

Thank you for your attention

Use of carbon dioxide in nuclear energy

Otakar Frýbort
Research Centre Řež

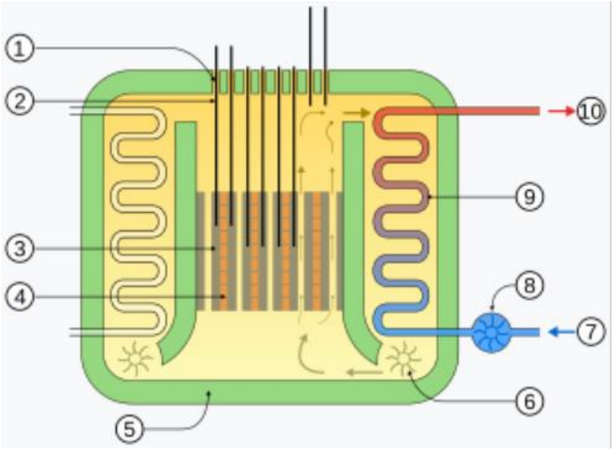
Summary

- Use of CO_2 in existing nuclear power plants
- General comparison of Rankin and EB cycle
- Nuclear reactor concepts under development using the sCO_2 power cycle
- Issues for implementation of sCO_2 cycles in nuclear energy
- Demonstration of sCO_2 cycles
- Conclusions

Use of CO_2 in existing nuclear power plants

Advanced Gas-cooled Reactor

- Designd and developed in UK
- The prototype was commissioned at Windscale in 1962
- Commercial use since 1976
- Core moderated by graphite
- CO_2 in gaseous phase used as a cooling media
- Power production through Rankine steam cycle



1. **Charge tubes**
2. **Control rods**
3. **Graphite moderator**
4. **Fuel assemblies**
5. **Concrete pressure vessel and radiation shielding**
6. **Gas circulator**
7. **Water**
8. **Water circulator**
9. **Heat exchanger**
10. **Steam**

https://en.wikipedia.org/wiki/Advanced_Gas-cooled_Reactor

Use of CO_2 in existing nuclear power plants

A1 – Jaslovske Bohunice

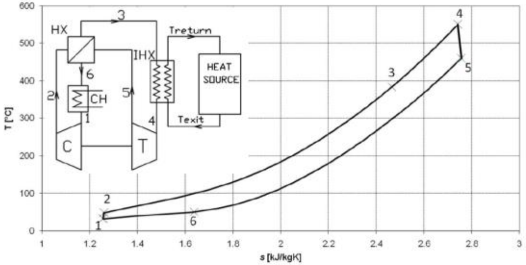
- Design developed in Czechoslovakia
- The pilot plant became operational at Jaslovske Bohunice in 1972
- Core moderated by heavy water
- CO2 in gaseous phase used as a cooling media
- Power production through Rankine steam cycle
- 100g of silica gel permanently stopped the reactor in 1977

The cross section of A1 nuclear powerplant

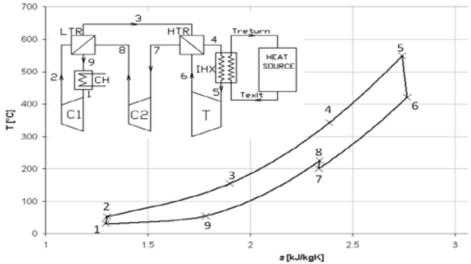
sCO_2 conversion cycle architecture

- Selection of the most suitable cycle layout depends on:
    - inlet temperature
    - required temperature drop
    - pressure level/ratio
    - thermal power

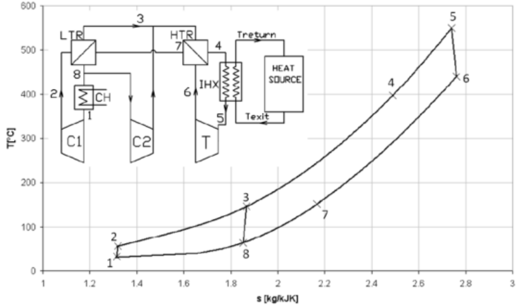
- The selected cycle architecture affects mainly:
    - cycle efficiency
    - total power of the cycle
    - investment demand



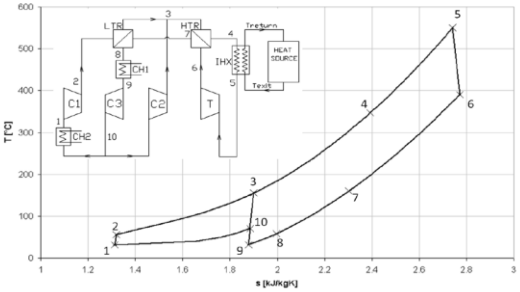
Simple Brayton Cycle Temperature - Entropy Diagram



Precompression Cycle Temperature - Entropy Diagram



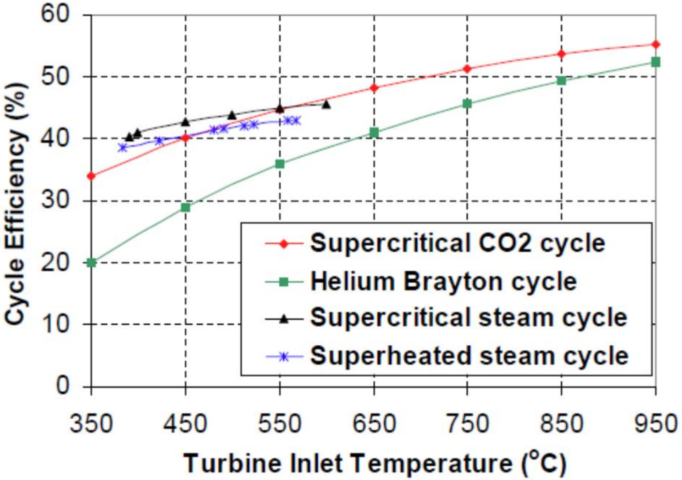
Recompression Cycle Temperature - Entropy Diagram



Partial-cooling Cycle Temperature - Entropy Diagram

General comparison of Rankin and EB cycle

- Subcritical steam cycles 42%
- Supercritical steam cycles less than 50%
- sCO_2 above 50% on high temperatures
- Other advantage of the sCO_2 cycle in comparison with SCW – mainly in dimensions and corrosion issues



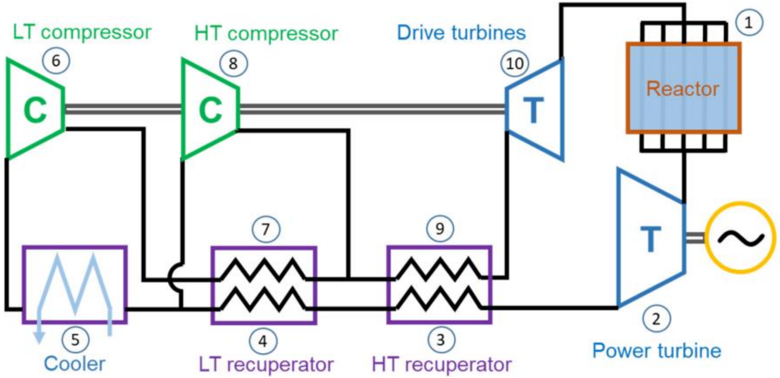
Cycle efficiency comparison of advanced power cycles

https://www.researchgate.net/figure/Cycle-efficiency-comparison-of-advanced-power-cycle-4_fig1_299509259

Nuclear reactor concepts under development using the sCO$_2$ power cycle

HWGTR

- Design by Terra Power, US
- Gas cooled fast reactor concept – compact reactor core design
- Thermal power of 500 MW
- Direct Brayton cycle
- Main sCO$_2$ parameters
    - Tmax – 550 °C
    - Pmax – 22.5 MPa
- Gross/Overall efficiency 41/36%



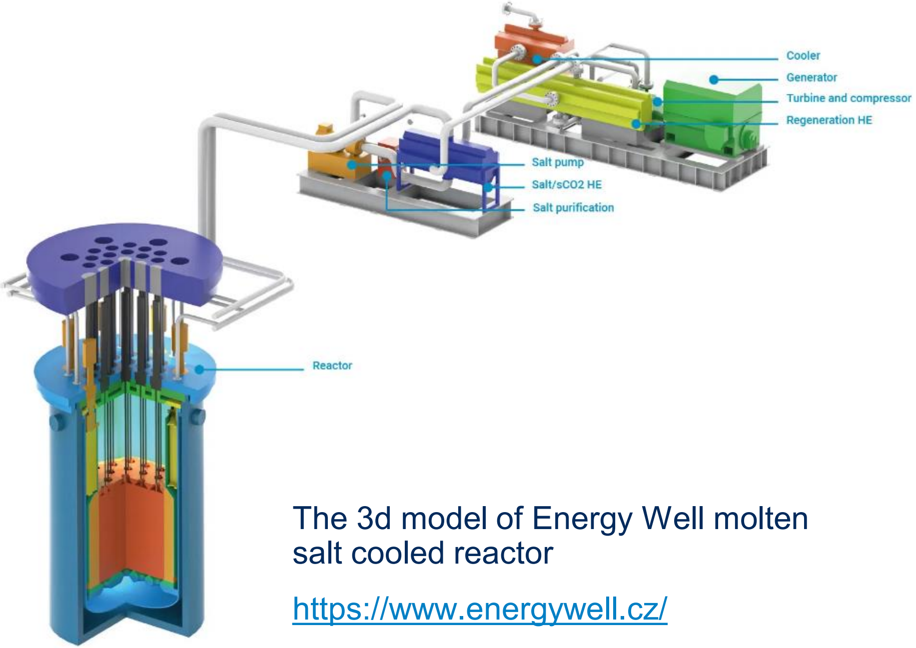
HWGTR power cycle schematic

https://www.sciencedirect.com/science/article/pii/S1738573321005702

Nuclear reactor concepts under development using the sCO$_2$ power cycle

Energy Well

- Design by CVR, Czech Republic
- Primary and secondary cycle - FLiBe salt
- sCO$_2$ power cycle is used for power generation
- Thermal power of 20 MW
- Main sCO$_2$ parameters
  - Tmax – 600 °C
  - Pmax – 25 Mpa
  - Efficiency – 40%



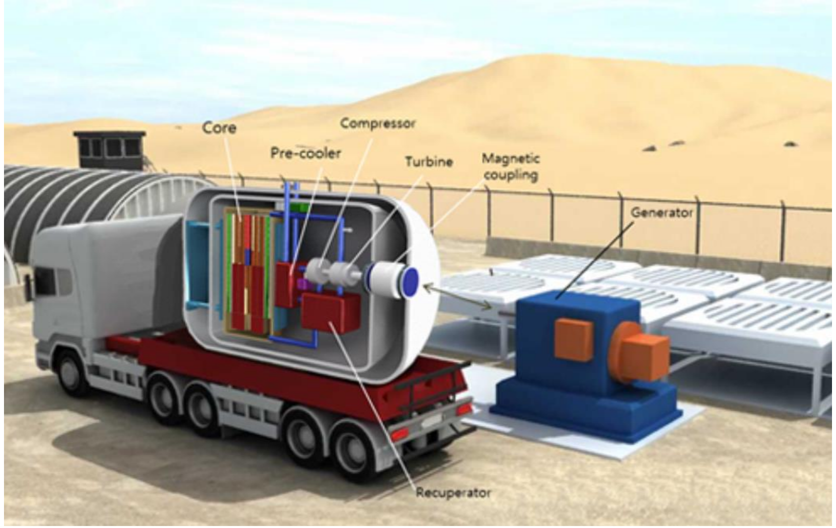
The 3d model of Energy Well molten salt cooled reactor

https://www.energywell.cz/

Nuclear reactor concepts under development using the sCO_2 power cycle

KAIST MMR - Supercritical CO2-cooled micro modular reactor

- Design by Kaist, South Korea
- Direct sCO_2 cycle
- Thermal power of 36 MW
- 20 years of operation without refueling
- Main sCO_2 parameters
  - Tmax – 650 °C
  - Pmax – 20 Mpa
  - Efficiency – 33%



Visualization of KAIST MMR

https://breakthroughs.kaist.ac.kr/sub02/view/id/278

Issues for implementation of sCO_2 cycles in nuclear energy

- Operation pressure of sCO_2 much higher than primary loop pressure
- Licencing
  - The technology is not fully verified
  - The long-term reliability hasn’t been demonstrated
  - It is mainly planned to be in connection with other non-validated technologies
  - Missing component reliability data

Demonstration of sCO_2 cycles

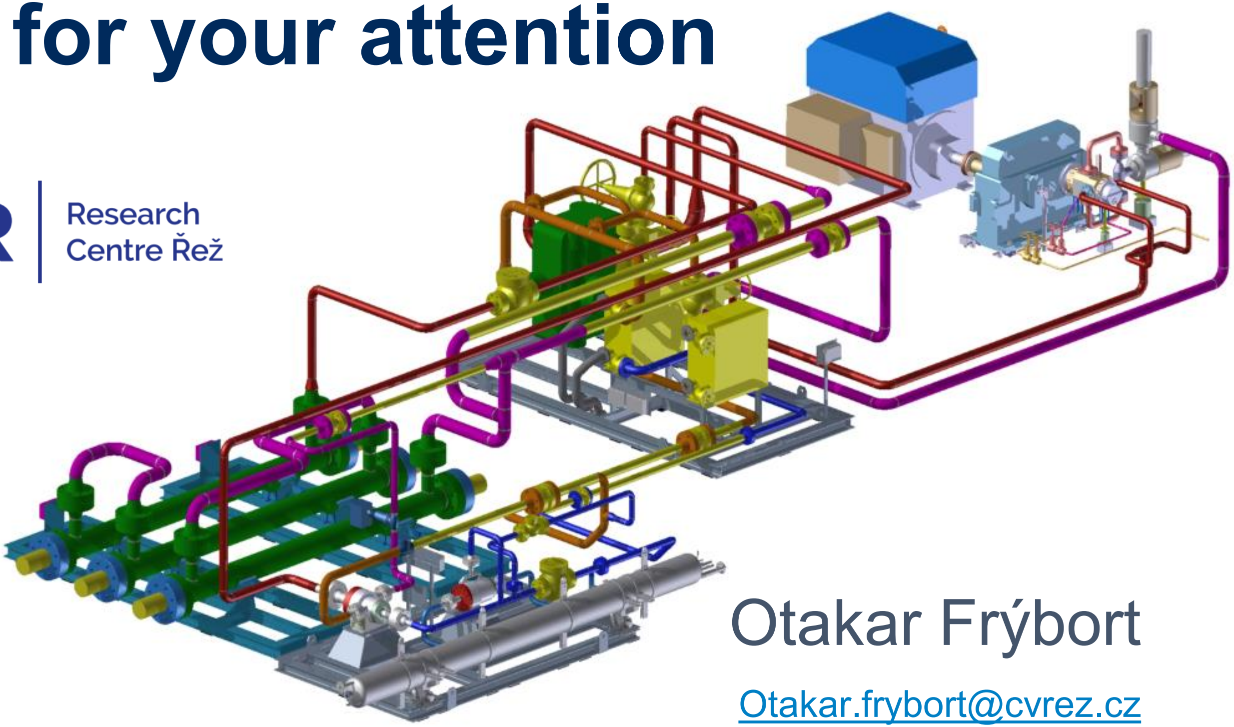
- Loops
  - SNL loop
  - Viena
  - sCO_2 loop at CVR
  - …
- Demonstration cycles
  - Step
  - Sofia
  - Solarscool H2020 project
  - Desolination H2020 project
  - …

- Possible applications for demonstration of the operability of the sCO_2 cycle
  - Waste heat recovery
  - Thermal energy storage
  - CSP applications
  - …

Conclusions

- Utilization of sCO_2 Brayton cycle is the way how to improve GIV NPP efficiency
- Use of sCO_2 cycle in PVRs or BWRs is not beneficial
- Before it’s application, the cycle needs to be fully verified in the labs and further in industrial application

Thank you for your attention



Otakar Frýbort

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sCO_2 for molten salt reactors

Paul LEVISSE
NAAREA

NAARREA a French company

providing an energy access service on an industrial scale.

Recycling of nuclear spent fuel

80 MW_{th} / 40 MW_e

Nuclear reactor
Fourth generation
molten salts
and fast spectrum

Stable & competitive price

n uclear
a bundant
a ffordable
r esourcefull
e nergy, for
a ll

NAAREA a French company

providing an energy access service on an industrial scale.

80 MW_{th} / 40 MW_e

Approximately 100,000 Western households

2700 buses or heavy goods vehicles

90 % of the industrial plants

The largest ships in the world fully loaded

110,000,000 m3 of desalinated water consumption of 2 million inhabitants

5,700 tonnes/year of carbon-free hydrogen.

NAAREA's Approach

1 A nuclear technology

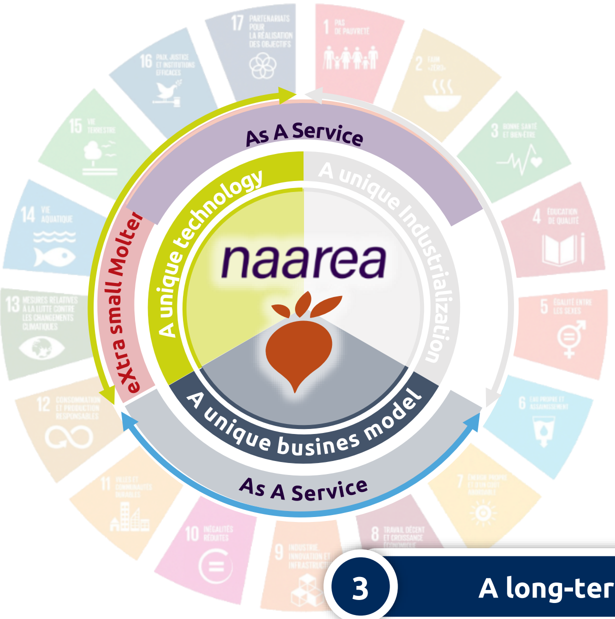
- Molten salt reactor → passive safety
- Fast spectrum → uses Nuclear spent fuel
- eXtra-small → reactor in a 40ft container
- 80 MWth / 40 MWe
- Water free / Pressure Free

Sustainable, distributed, dispatchable, safe energy

2 A serial industrial approach

- Centralized In-factory build → Reliability
- Standard module → flexible deployment and easy maintenance
- limited Civil work → Fast Installation and decommissioning

Reliable, competitive, simplified deployment



3 A long-term Service business model

- Access to Carbon free resilient energy
- Long-term contract → No trading impact

NAAREA has the responsibility of the full cycle

newcleo Futurable Energy

THORIZON

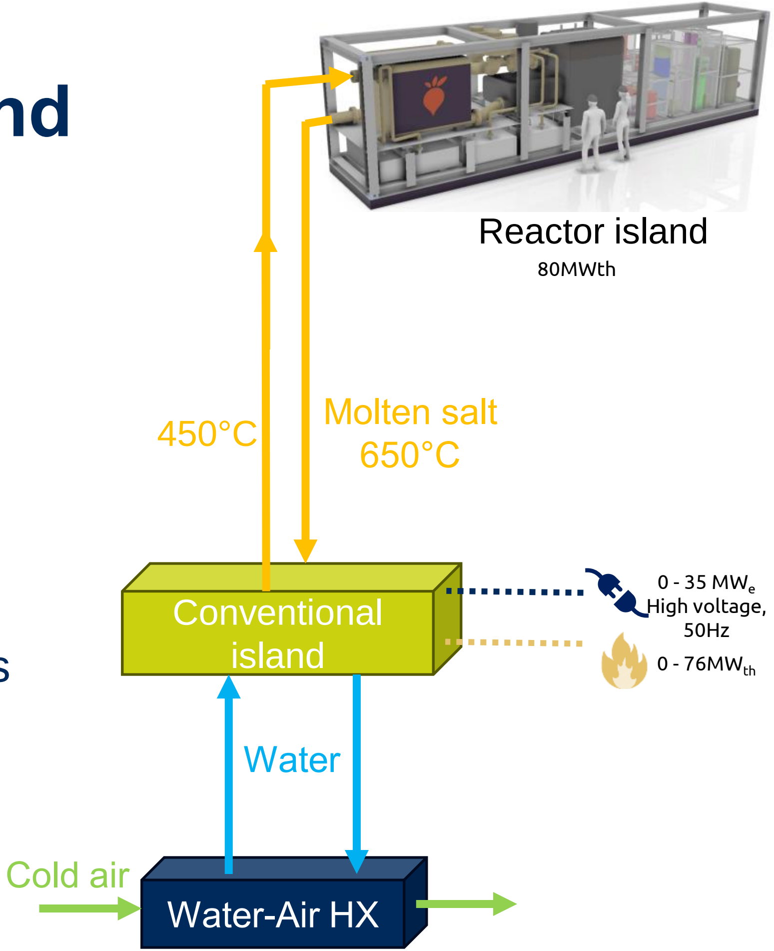
Why sCO_2 ?

NAAREA’s conventional island

- Reactor island interface :
  - 80MWth molten chloride salt (650°C)
  - Molten salt coming out of the reactor island is non-radioactive and non-contaminated

- Power conversion island :
  - Recompression Brayton sCO2 cycle
  - Directly coupled to the grid
  - Electricity and/or heat
  - Load variations to follow client requirements
  - No nuclear safety requirements on conventional island

- Cycle cooling :
  - Air cooled w/ intermediate water loop



Why sCO_2 with Molten Salt SMRs

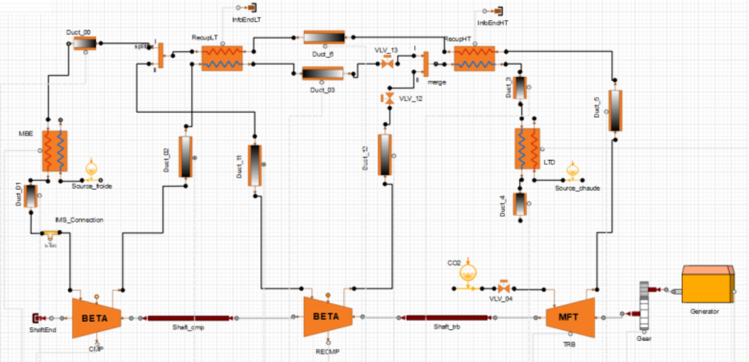
	Characteristic of molten salt SMR	Synergy with sCO2 cycle
Temperature	High temperature fluid with operating range between 400°C and 700°C	sCO2 displays significant efficiency benefit vs steam >550°C (SCW costly in <200MWth range) Good matching between molten salt temperatures and CO2 temperatures across main heater
Compacity	Molten plutonium salts enable for very compact reactors → Container implantation for reactor island	sCO2 enables compact turbomachinery and conventional island → Reduce overall footprint of plant for installation on industrial sites
Reactivity	Fast neutron molten salt reactors can react rapidly to load changes (no Xe poisoning, limited thermal inertia)	sCO2 transient response seen as faster than steam (lower inertias)
Installation	80MWth reactors are to be installed as close as possible to end users (industries, …), sometimes in remote areas	Absence of water use for cooling or make-up water reduces installation constraints and increases resiliency

sCO_2 development for NAAREA (1/2)

- R&D :
  - Salt-sCO_2 interaction (calculations, tests)
  - Potential specific sCO_2 – material corrosion tests

- sCO_2 steady and transient model :
  - Definition of design parameters vs techno-economic optima :
    - Turbine inlet temperature vs material costs
    - Compressor inlet temperature vs dry cooling surface vs hot day performance
    - Recuperator pinch vs cost

  - Strategies for main transient and accidental conditions :
    - Reactor shutdown (avoid salt freeze)
    - Turbine trip / load rejection : no power extraction from reactor
    - Coupled reactor + turbine control
    - Client load following (heat & electricity)



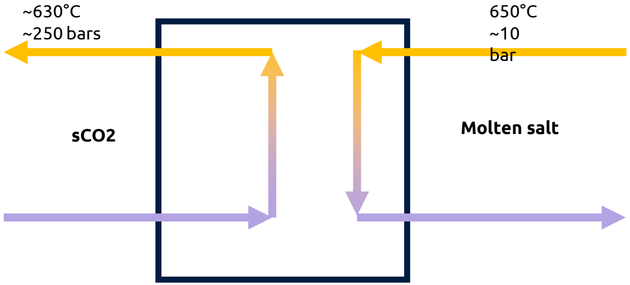
sCO_2 development for NAAREA (2/2)

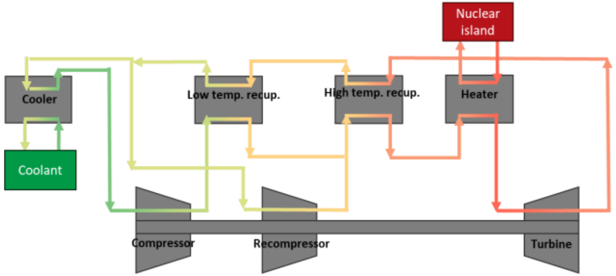
- Overall integration :
  - NAAREA positioned as EPC & operator
  - Turbomachinery, heat exchangers and other equipment designed and manufactured by dedicated suppliers

- Main challenges :
  - Demonstration of techno-economic competitivity : difficulty in projecting equipment CAPEX & OPEX for series production
  - No off-the-shelf solutions available for turbomachinery and heat exchangers : specific FEED studies & supply chain development

Focus on MSR specific challenge : salt-sCO$_2$ heat exchanger

- At the crossroad of multiple challenges :
  - Corrosion resistance :
    - Molten salts corrode most alloys (highly dependent on salt purity)
      - Chloride salts are especially aggressive
    - sCO$_2$ has specific high temperature corrosion mechanisms (carburisation, …)
  - High pressure and high temperatures
  - Compacity and costs
  - Manufacturability
  - Salt side must be drainable





Thank you for your attention

ETN PRESENTATION FUSION ENERGY AND THE ROLE OF SCO_2

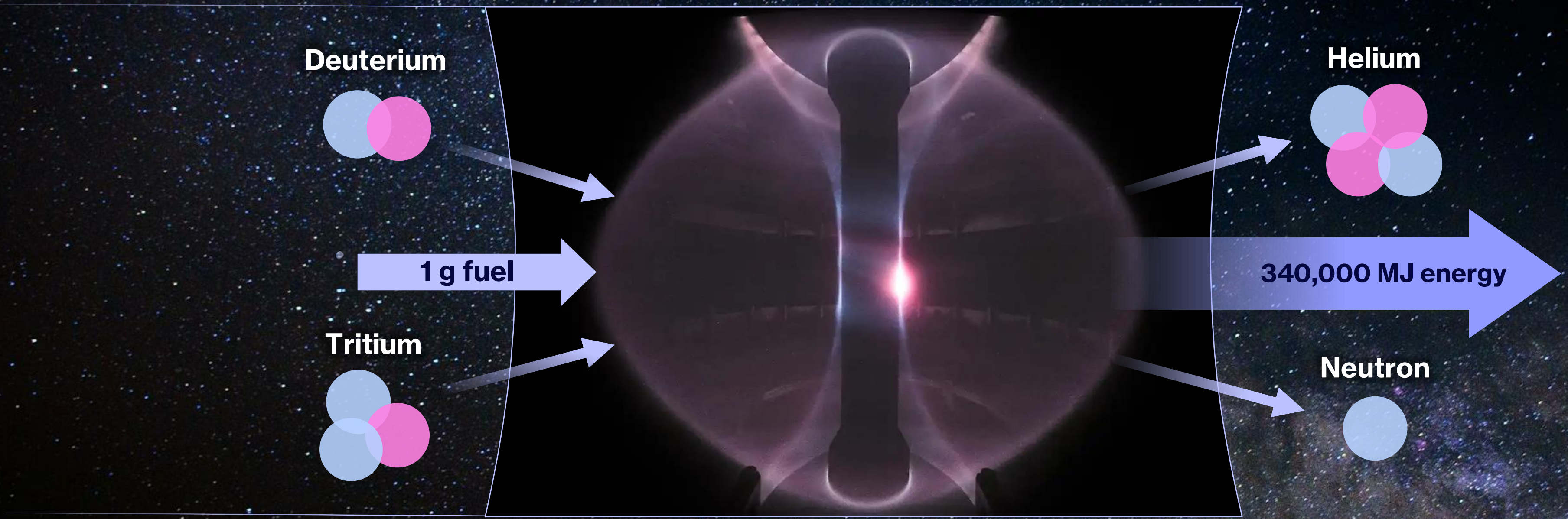
FOR PUBLIC USE

UKAEA - STEP – Power & Cooling

Jack Acres

WHAT IS FUSION

Fusion is the process that powers the sun and stars by fusing hydrogen nuclei at the core…



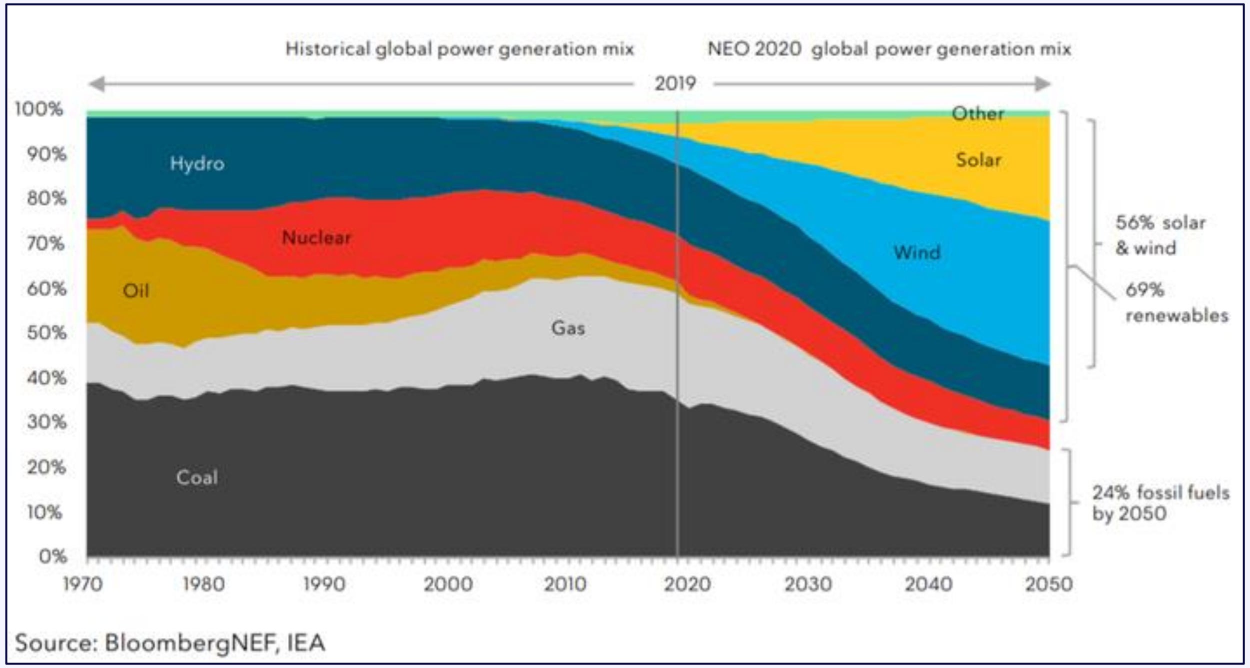
$${}^{2}_{1}H + {}^{3}_{1}H \rightarrow n\,(14.1\ MeV) + {}^{4}_{2}He\,(3.5\ MeV)$$

… unlike its fission counterpart, fusion relies on fusing two lighter atomic particles. The mass deficit of the subatomic particles releases energy (e=mc2)

PAGE TITLE

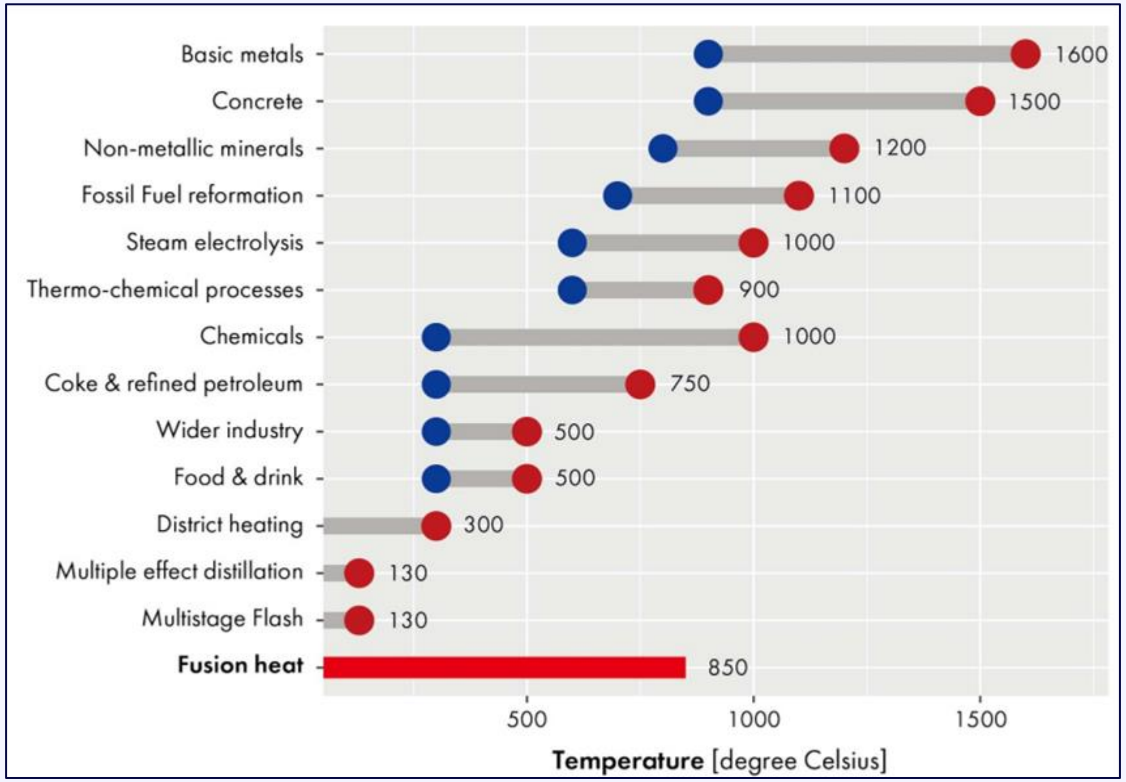
WHY FUSION? FUSION POWER IN A GLOBAL DEMAND FOR CLEAN ENERGY

GLOBAL ELECTRICITY MIX



New Energy Outlook Projects Massive Energy Sector Shift Through 2050 - forbes.com - Robert Rapier
https://www.forbes.com/sites/rrapier/2020/10/31/new-energy-outlook-projects-massive-energy-sector-shift-through-2050/

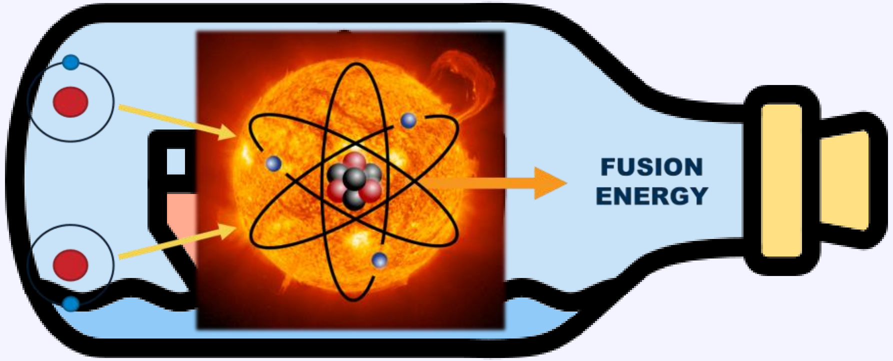
TEMPERATURE DISTRIBUTION OF HEAT DRIVEN INDUSTRIAL PROCESSES



The commercialisation of fusion for the energy market: a review of socio-economic studies
Thomas Griffiths, Richard Pearson, Michael Bluck and Shutaro Takeda

A GLOBAL DEMAND FOR RELIABLE, DISPATCHABLE, AND SAFE CLEAN ENERGY — ALLOWING US TO REACH NET ZERO

HOW TO DO FUSION: FUSION ON EARTH



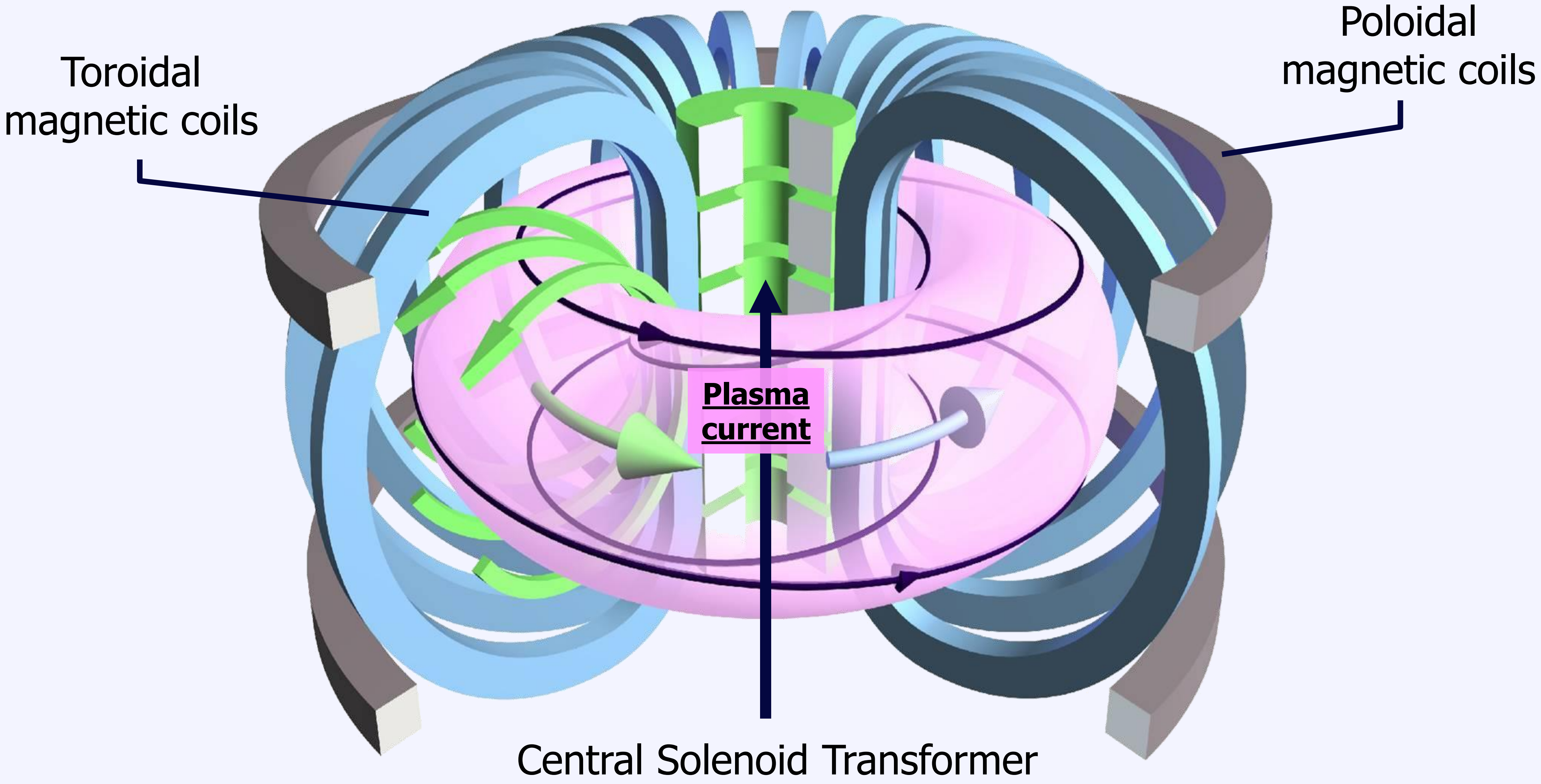
Fusion in the sun occurs at immense pressures and temperatures. At these conditions, the hydrogen is in a “plasma” state (ionised and stripped of its electron).

Recreating fusion on earth requires:

- High vacuum to remove impurities and cooling effect
- Very high temperatures, 10x higher than the centre of the sun, due to lower achievable plasma pressures (100-150 Million °C)
- Deuterium and tritium. Deuterium is widely available naturally. Tritium will need to be bred locally to sustain the high energy value of the D-T reaction

THIS IS ACHIEVED BY USING VARIOUS CONFINEMENT TECHNIQUES SUCH AS MAGNETIC AND/OR INERTIAL CONFINEMENT

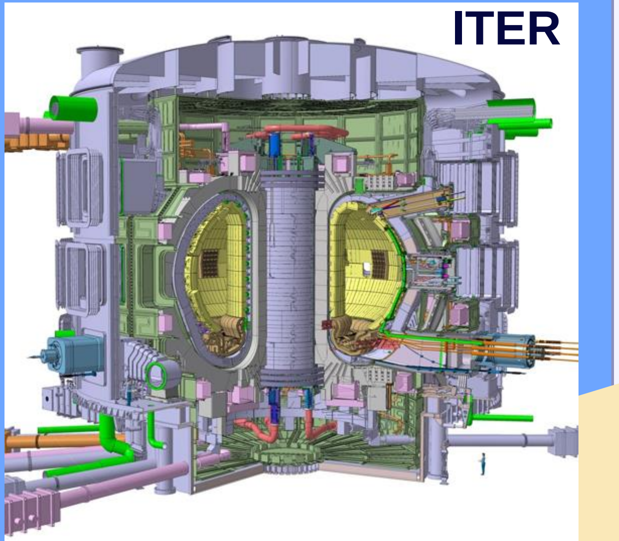
HOW TO DO FUSION: THE TOKAMAK



WHO IS DOING FUSION: GLOBAL FUSION ROADMAP

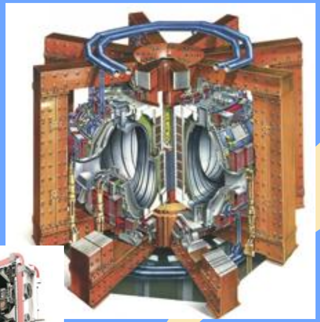
2020 2030 2040 2050

EXPERIMENTAL DEVICES

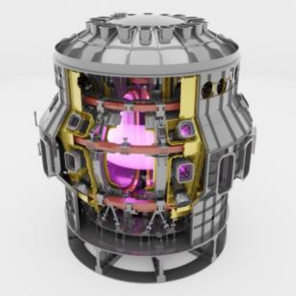


ITER

JET



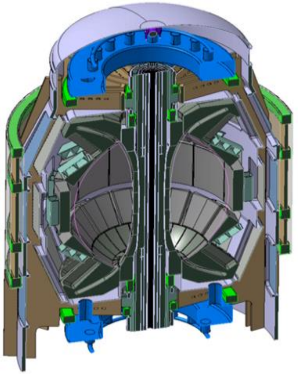
MAST-U



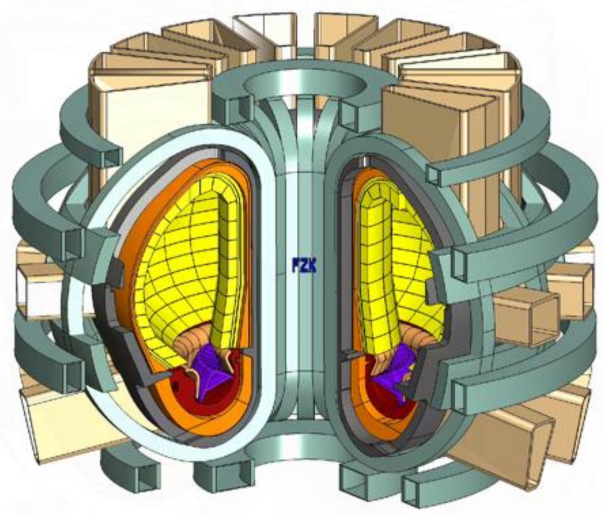
JT-60SA
& others
supporting ITER…

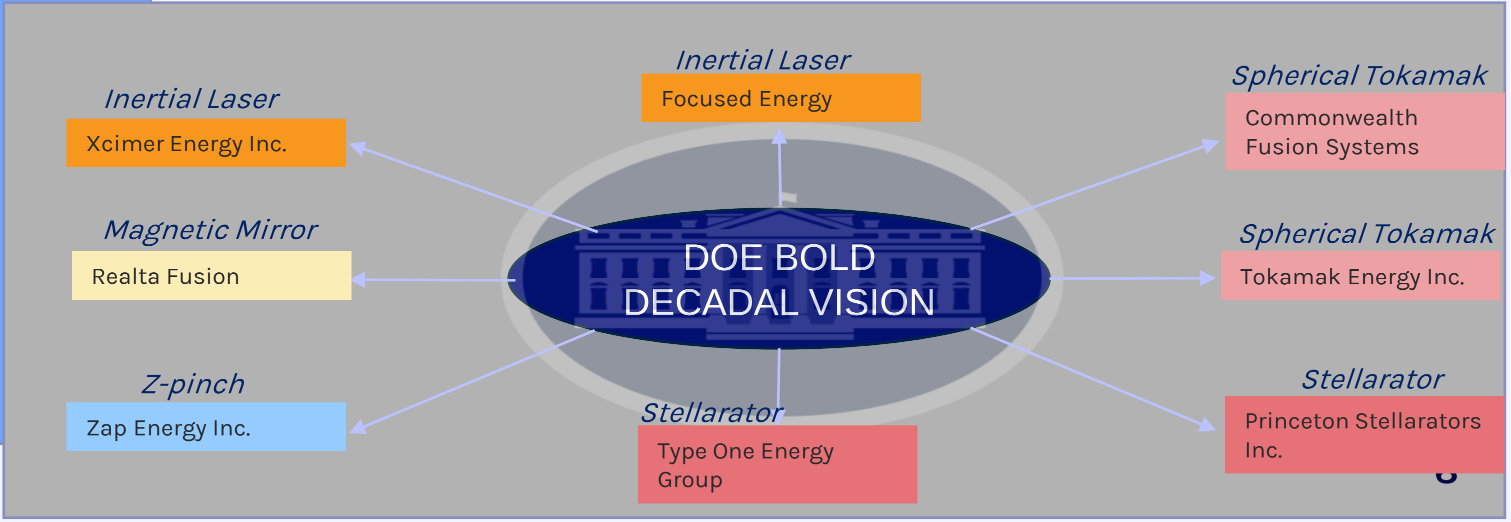
POWER PLANTS

STEP



DEMO





DOE BOLD DECADAL VISION

Inertial Laser
Xcimer Energy Inc.

Magnetic Mirror
Realta Fusion

Z-pinch
Zap Energy Inc.

Inertial Laser
Focused Energy

Stellarator
Type One Energy Group

Spherical Tokamak
Commonwealth Fusion Systems

Spherical Tokamak
Tokamak Energy Inc.

Stellarator
Princeton Stellarators Inc.

WHAT IS STEP?

DELIVER A UK PROTOTYPE FUSION ENERGY PLANT, TARGETING 2040, AND A PATH TO COMMERCIAL VIABILITY OF FUSION.

STEP MISSION

WHAT IS STEP?

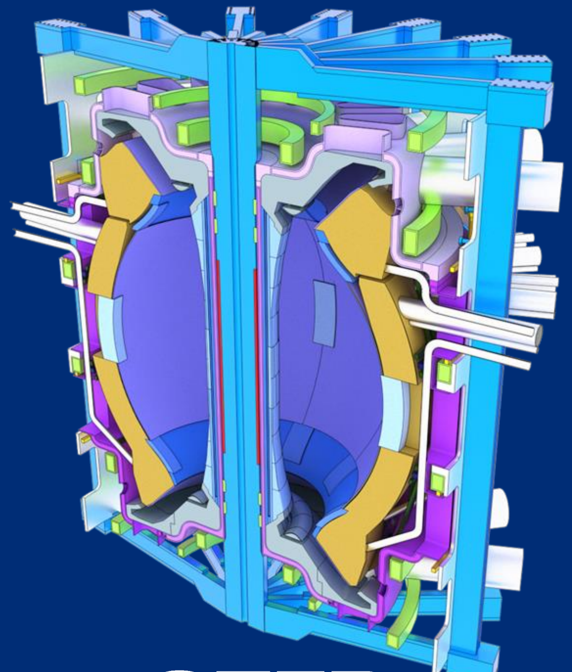
SPHERICAL TOKAMAK FOR ENERGY PRODUCTION

A pioneering, prototype fusion powerplant that will demonstrate:
- net energy,
- fuel self-sufficiency
- maintainability of fusion power plants
- a route to the commercial viability of fusion

STEP has progressed through five Concept Maturity Level reviews and three independent Fusion Technical Advisory Group reviews.

STEP will be delivered in 3 phases:
Phase 1 – develop concept design and select a site
Phase 2 – detailed engineering design and permissions and consents as well as pre-construction works by early 2030s
Phase 3 – manufacturing and construction – targeting operations around 2040.

SPHERICAL TOKAMAK BASIS



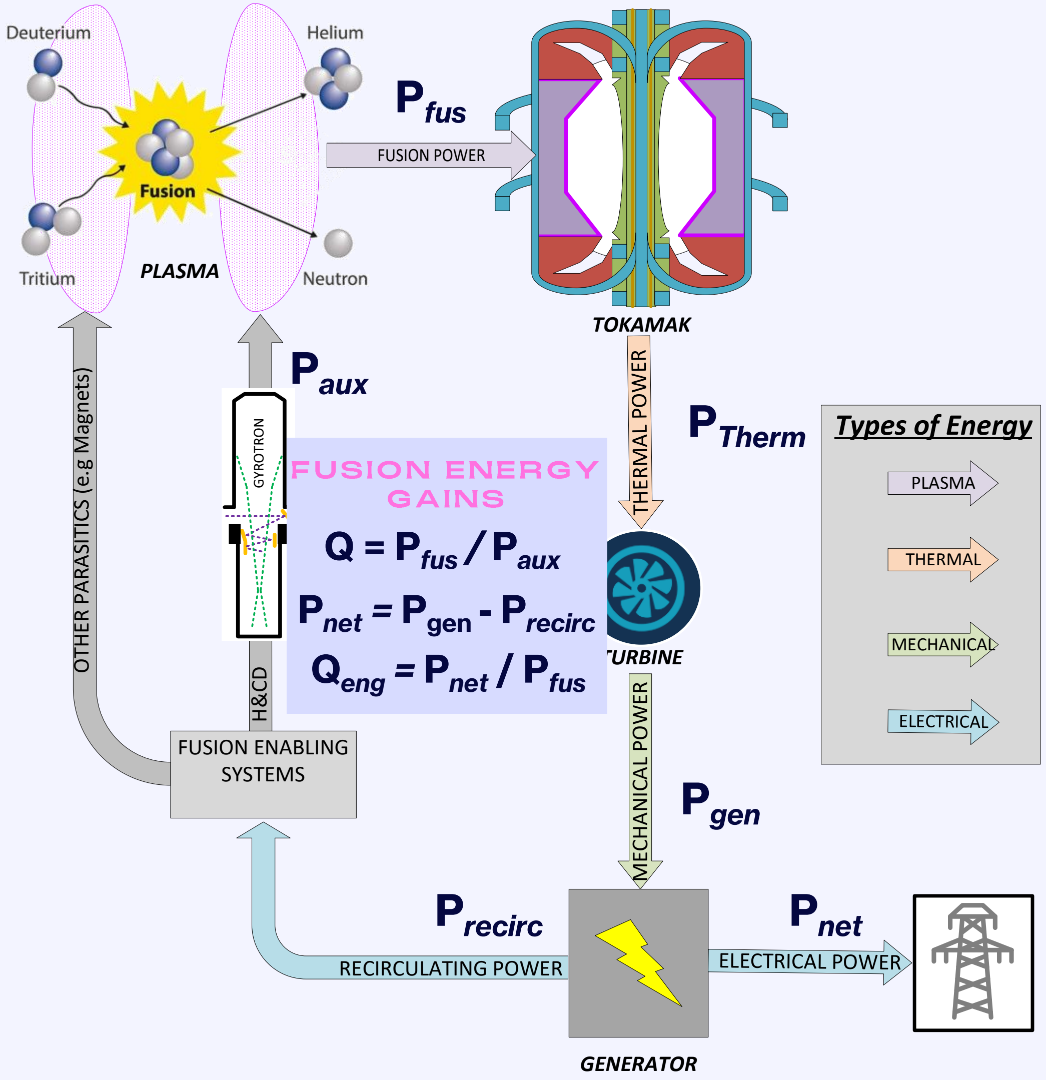
STEP

- Cored apple shape
- Novel exhaust options – Super-X Divertor
- Fewer, smaller magnets
- Smaller buildings
- Lower costs due to compact nature

STEP

THE STEP POWERPLANT

MAGNETICALLY CONFINED FUSION
A UNIQUE POWER SOURCE



FUSION ENERGY GAINS

$Q = P_{fus} / P_{aux}$

$P_{net} = P_{gen} - P_{recirc}$

$Q_{eng} = P_{net} / P_{fus}$

4 KEY CHALLENGES UNIQUE TO FUSION POWER GENERATION:

Challenge 1: Need for efficiency

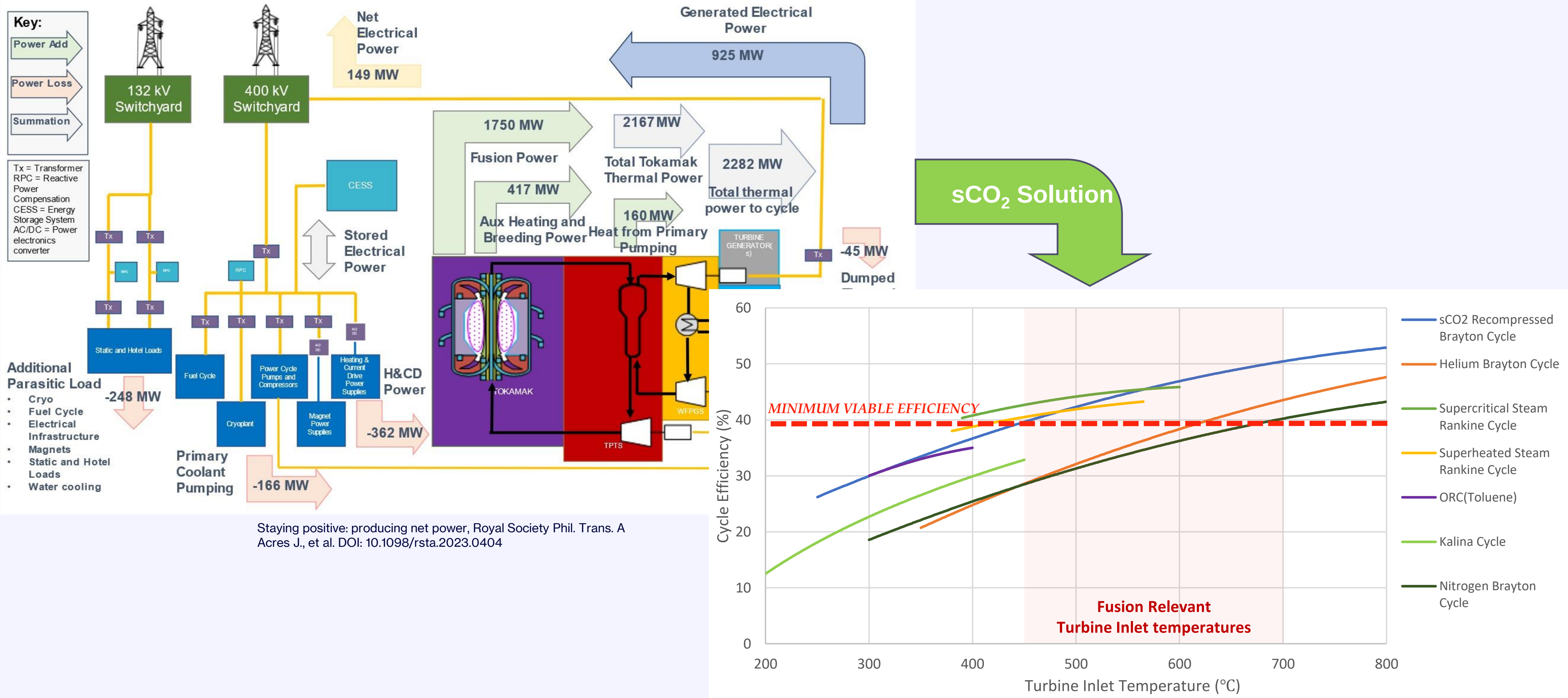
Challenge 2: Need for heat integration

Challenge 3: Need for flexibility

Challenge 4: Needs for viability

GT2024-126730 Fusion Energy and Future Fusion Power Plants, ASME Turbo Expo 2024
Jack Acres, Chris Clements; https://doi.org/10.1115/GT2024-126730

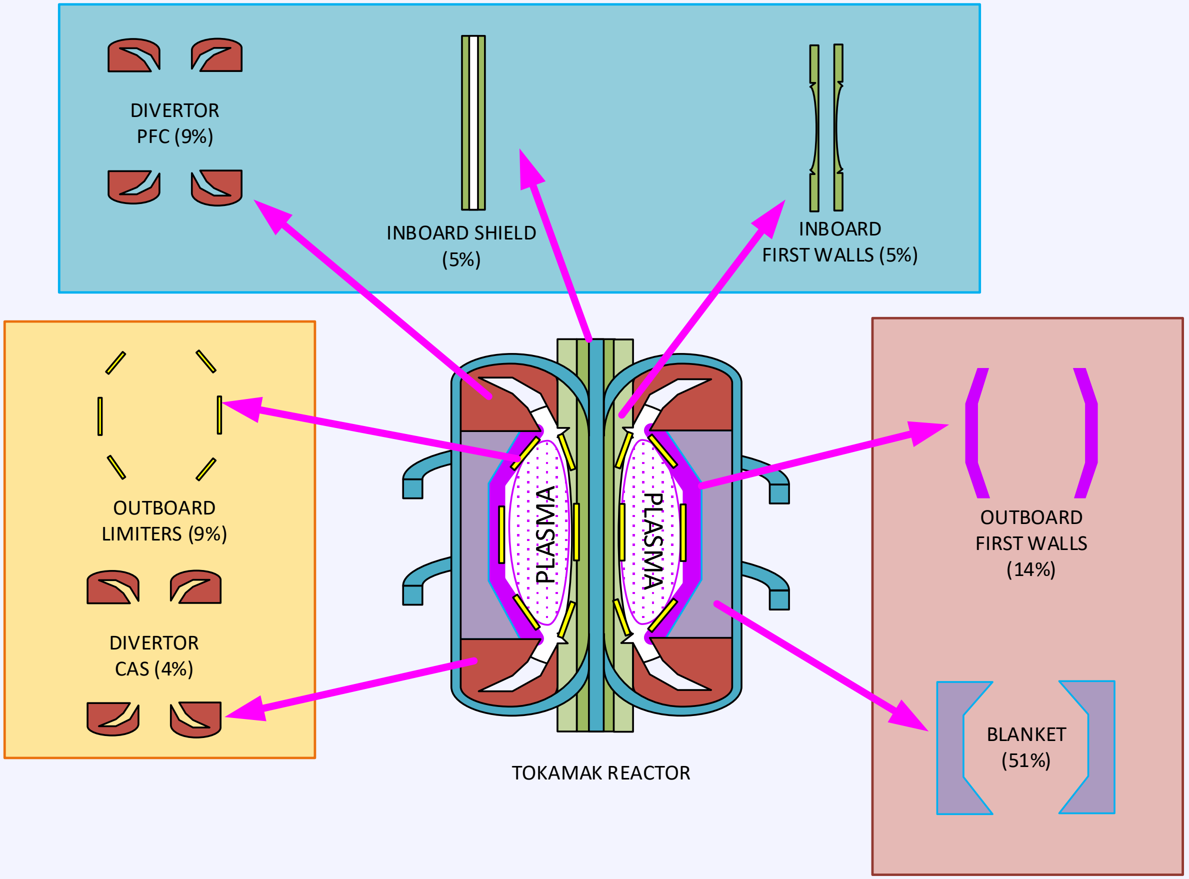
NEED FOR EFFICIENCY: DRIVEN BY THE POWER BALANCE



Staying positive: producing net power, Royal Society Phil. Trans. A
Acres J., et al. DOI: 10.1098/rsta.2023.0404

Staying positive: producing net power, Royal Society Phil. Trans. A
Acres J., et al. DOI: 10.1098/rsta.2023.0404

NEED FOR HEAT INTEGRATION DRIVEN BY THE TOKAMAK ARCHITECTURE



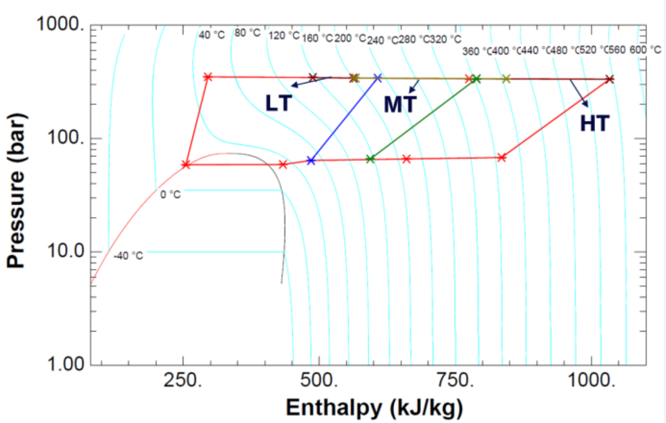
🟥 HELIUM COOLED HIGH GRADE HEAT (450 - 600°C)

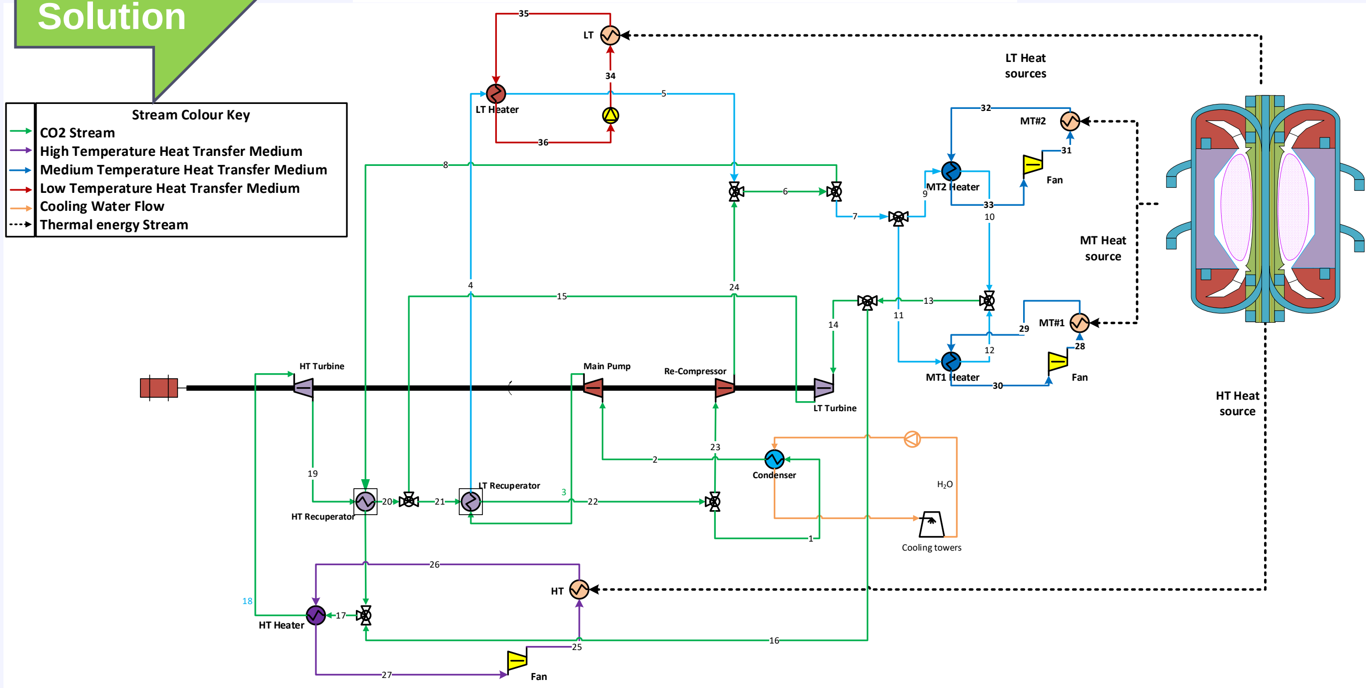
🟧 HELIUM COOLED MEDIUM GRADE HEAT (250 - 400°C)

🟦 WATER COOLED LOW GRADE HEAT (150-250°C)

The Challenges of Developing a Fusion Power Plant: and How Chemical Engineers are Helping Make STEP a Reality, The Chemical Engineer, pp. 24-28, J. Acres

sCO_2 Solution

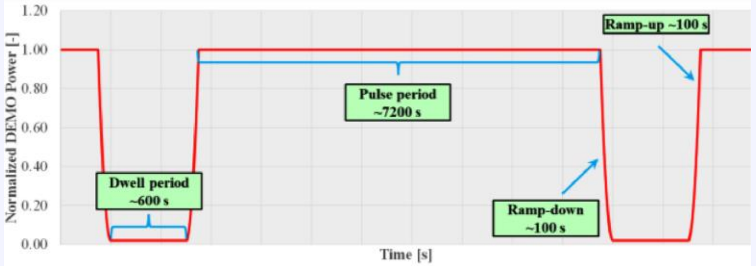




Power Cycle Design Modelling and Evaluation with Spherical Tokamak Concepts for STEP, SOFT 2024
Dhinesh Thanganadar, Jack Acres

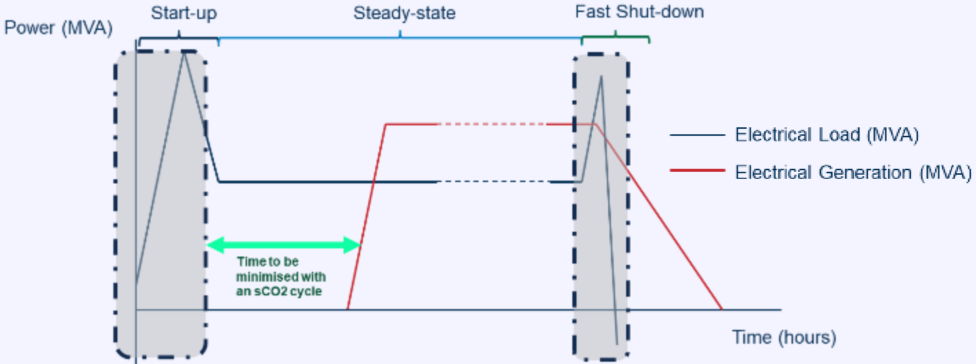
NEED FOR FLEXIBILITY DRIVEN BY THE TOKAMAK OPERATIONS

1. Inherently pulsed



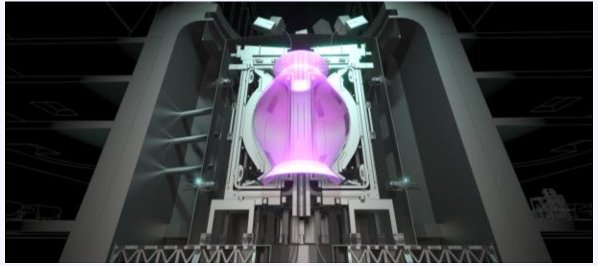
Maturation of critical technologies for the DEMO balance of plant systems, Fusion Engineering and Design, Volume 179, 2022; L. Barucca et al.

2. Rapid operational dynamics (startup/shut down)

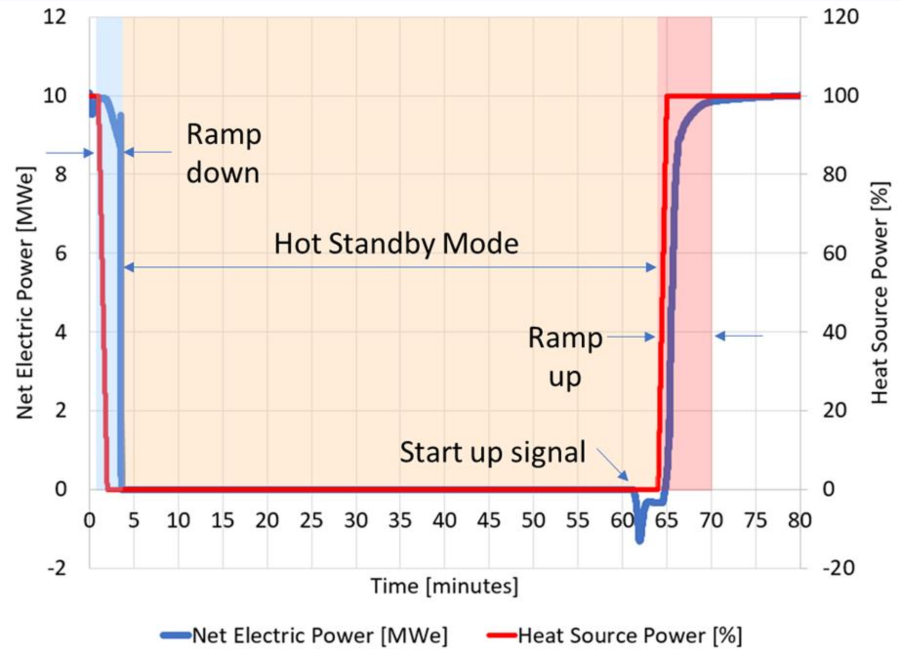


sCO2 in fusion , sCO2 symposium 2024, J. Acres C. Clements https://sco2symposium.com/proceedings2024/chris-clements-jake-acres.pdf

3. Prototypic operations



sCO_2 Solution



Rapid ramp rates of the sCO_2 power cycle could effectively support challenging operating scenarios

Evaluation on the rapidity of sCO2 cycle power up and down events using the STEP dynamic simulation model, sCO2 Symposium 2024 M. McDowell, J. Acres https://sco2symposium.com/proceedings2024/59-paper.pdf

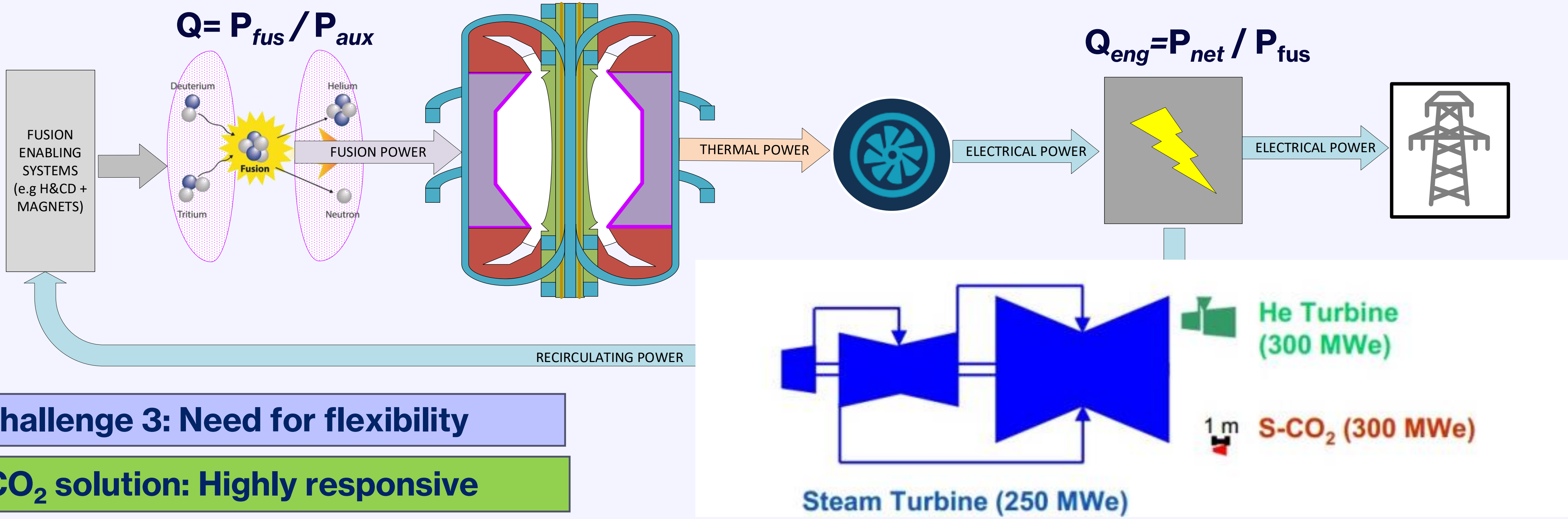
SCO2 UNIQUELY POISED TO ANSWER FUSION POWER GENERATION CHALLENGES?

Challenge 1: Need for efficiency

sCO_2 solution: High efficiency

Challenge 2: Need for heat integration

sCO_2 solution: Able to integrate heat



$Q= P_{fus} / P_{aux}$

$Q_{eng}=P_{net} / P_{fus}$

Challenge 3: Need for flexibility

sCO_2 solution: Highly responsive

Dostal, Vaclav, Michael J. Driscoll, Pavel Hejzlar. “A supercritical carbon dioxide cycle for next generation nuclear reactors.” PhD diss., Massachusetts Institute of Technology, Department of Nuclear Engineering; 2004.

STEP

THANK YOU, ANY QUESTIONS?

JACK.ACRES@UKAEA.UK

Thank you and see you next time!

Question / comments?

js@etn.global