IAEA
International Atomic Energy Agency

ABDAN Nuclear Summit
28 April 2022 (16:30 Vienna time)

Non-Electric Applications of SMRs

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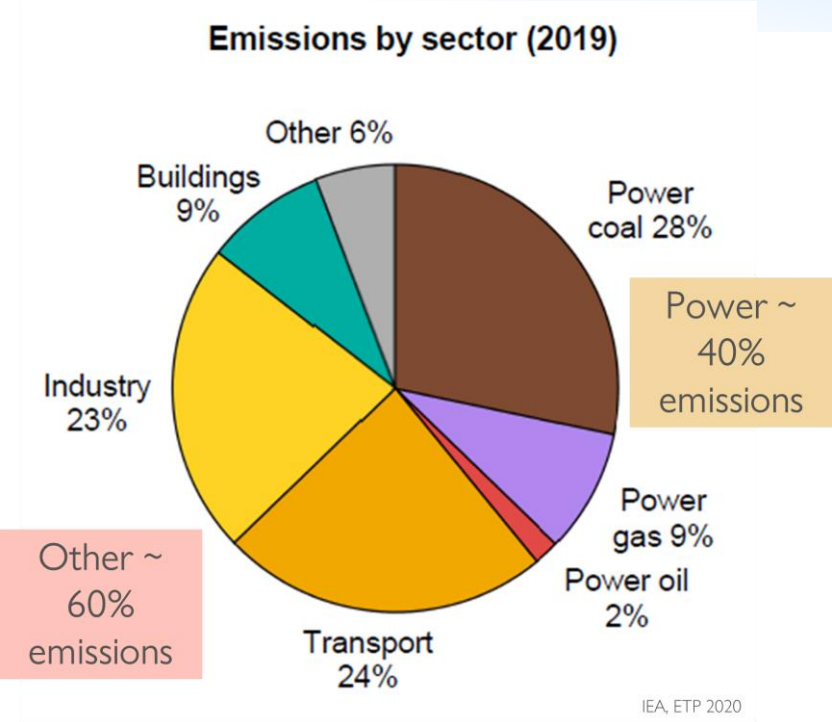
Nuclear beyond electricity
The IAEA project on non-electric applications

- Most trajectories to net zero require massive amounts of low-carbon electricity but decarbonising the power sector will not be sufficient.

- Hence there is also a need for low carbon heat & low carbon fuels – and the technologies to produce them - for the "**hard to abate sectors**" that cannot be easily electrified (e.g. industry-steel, cement, marine & air transport, etc.).

- Nuclear energy's low carbon heat potential mostly untapped until now.

- Non-electric applications have the potential to vastly increase the efficiency of nuclear generation, making good use of waste heat.



Size characteristics of the industrial heat market

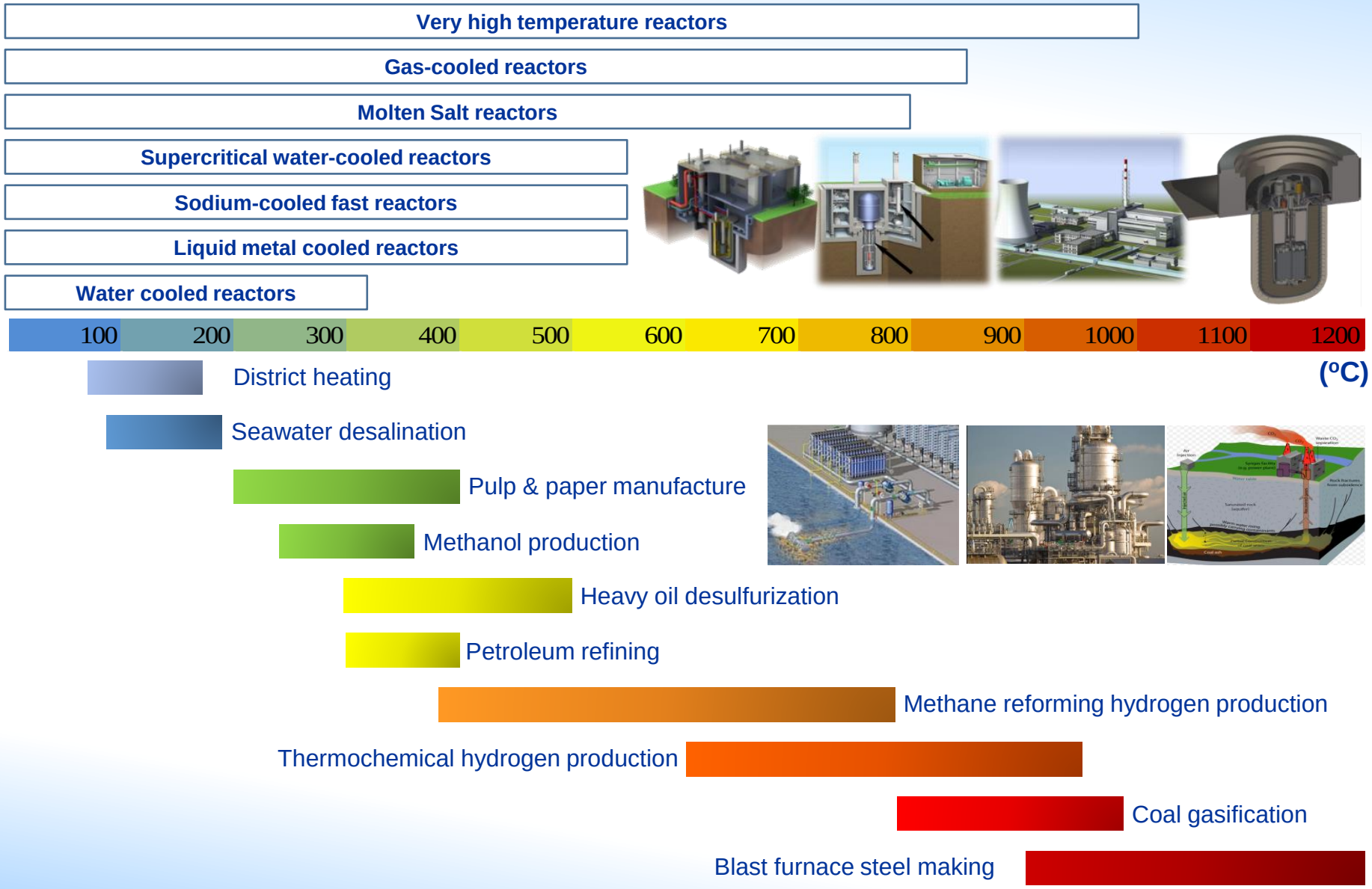
- 50% of the users for industrial processes require less then 10 MWth capacities.
- 40% require between 10 and 50 MWth.
- 99% of the users are included in the 1 to 300 MWth range, which accounts for about 80% of the total energy consumed.

The nature of industrial heat market is highly fragmented, hence very much suitable for SMR

- Individual large users with energy intensive industrial processes (**Desalination, petrochemical, district heating…etc**) cover the remaining portion of the industrial heat market with requirements up to 1000 MWth, and exceptionally even more.

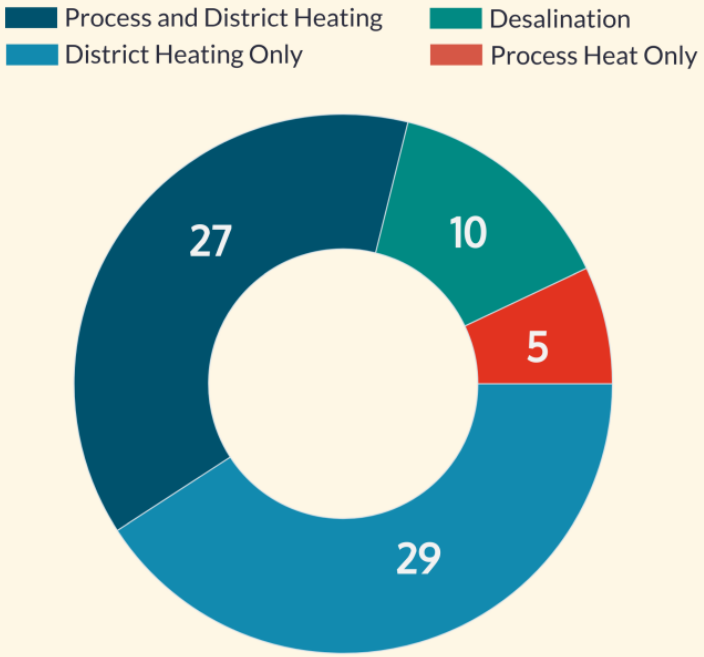
Large reactors for cogeneration in industrial parks

Reactor Technologies for Non-Electric Applications

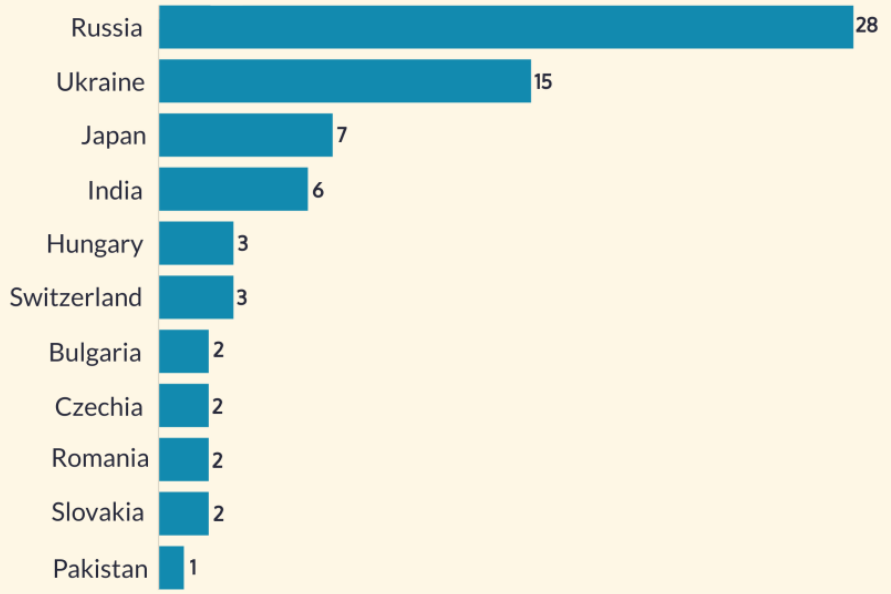


Non-electric Applications – Global Overview

Types of Non-Electric Applications
per reactor



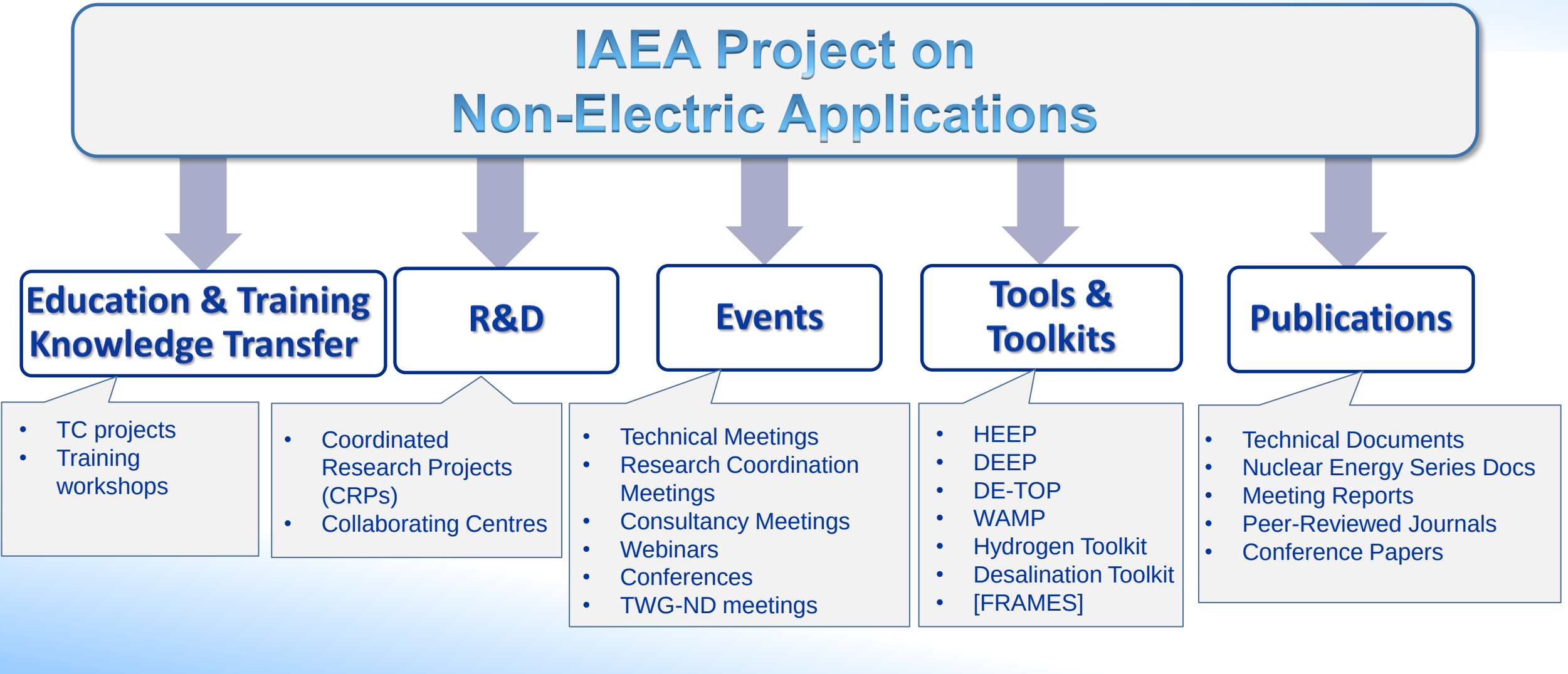
Reactors with Non-Electric Applications
by country



1%
OF AVAILABLE NUCLEAR HEAT HAS BEEN USED

Proven technology: about **70** reactors used in cogeneration and over **750** reactor-years experience

Activities of IAEA Project on Non-Electric Applications



Nuclear cogeneration

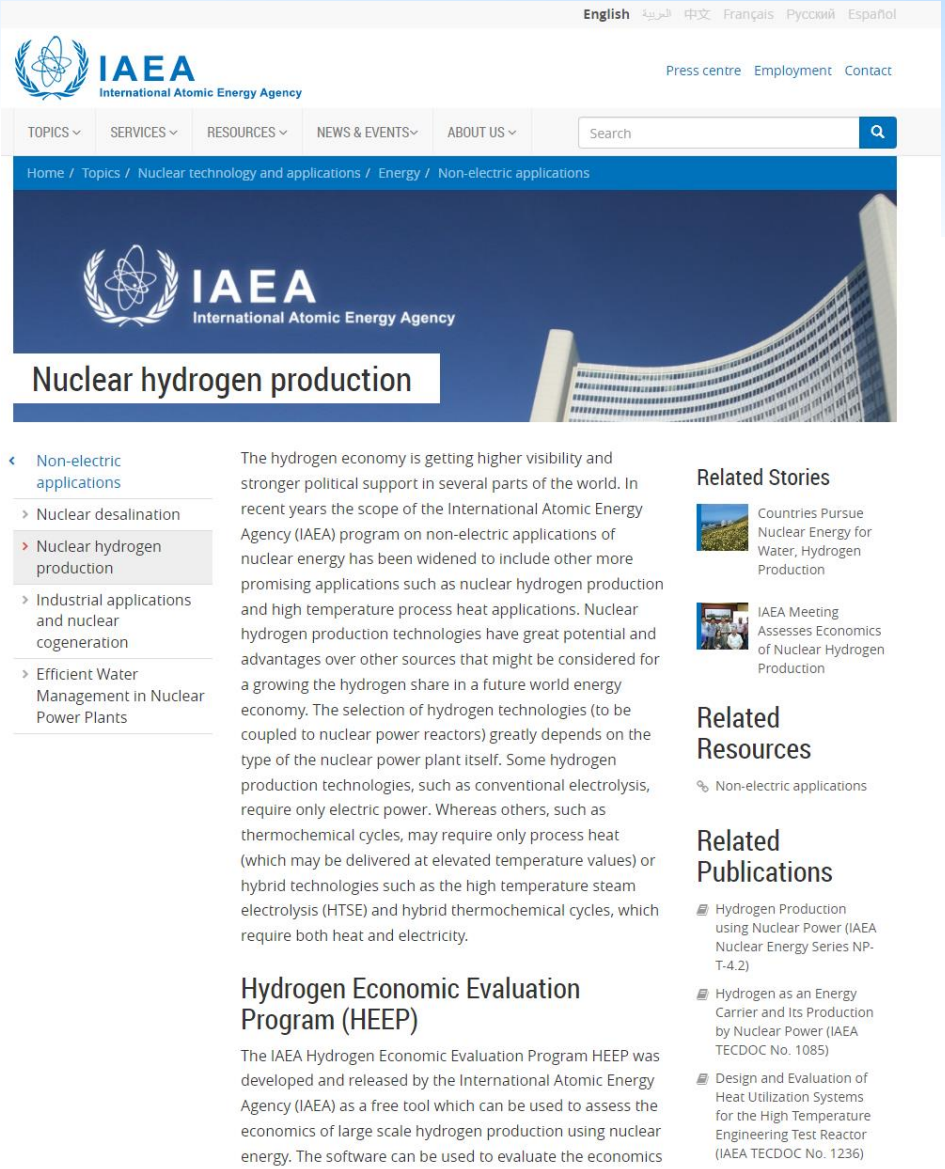
Publications	• **NES - Industrial Applications of Nuclear Energy (2017)** • **NES - Opportunities for Cogeneration with Nuclear Energy (2017)** • **NES - Guidance on Nuclear Cogeneration (2019)** Upcoming: • **Vendor and User Responsibilities in Nuclear Cogeneration Projects (NES)** • **Nuclear cogeneration to support climate change mitigation and SDGs (NES)**
Tools & Toolkits	Identification of coupling configurations and analysis of heat extraction and power production • **DE-TOP**
R&D	Coordinated Research Projects Just started (March 23rd): • **Role of Nuclear Cogeneration within the Context of Climate Change (2022-2026)** Collaborating Centres: • **Ontario Tech University (Canada) – launch event 02.11.2021**
Education & Training, Knowledge Transfer	• **Non-Electric Applications of Nuclear Power (ICTP NEM School, 28.06-09.07.2021)** • **TC INT2021001: Supporting Member States' Capacity Building on Small Modular Reactors and Micro-reactors and their Technology and Applications – A Contribution of Nuclear Power to the Mitigation of Climate Change**
Events	• **Technical Meeting on Potential Schemes for Licensing Nuclear Cogeneration Plants (March 29-31, 2021)** • **Webinar on Nuclear Heat to Decarbonize the Energy Sector (July 13, 2021)** • **Technical Meeting on the role of nuclear cogeneration applications towards climate change mitigation (October 11-13, 2021)** Upcoming • **Technical Meeting on the Planning and Implementation of Nuclear Cogeneration Projects (May 30 – June 01, 2022)** • **First Research Coordination Meeting on the Coordinated Research Project on Nuclear Cogeneration for Climate Change Mitigation (November 22-25, 2022)**
To be addressed	• **Review of the IAEA Milestones in the Development of a National Infrastructure for Nuclear Power to address aspects of nuclear cogeneration projects** • **Safety approach for licensing of nuclear cogeneration projects**
Cross-links	• **IAEA wide platform on SMR and their applications** • **TWG-SMR, TWG-GCR** • **GIF**

Nuclear desalination and water management

Publications	• **TECDOC – New Technologies for Seawater Desalination Using Nuclear Energy (2015)** • **NES – Efficient water management in WCR (2012)** • **TECDOC – Status of Nuclear Desalination in IAEA Member States (2007)** • **TECDOC – Economics of Nuclear Desalination (2007)** • **TECDOC – Optimization of the coupling of nuclear reactors and desalination systems (2005)** • **TECDOC – Status of design concepts of nuclear desalination plants (2002)** • **TECDOC - Safety Aspects of Nuclear Plants Coupled with Seawater Desalination Units (2001)** • **Tech Rep Series - Introduction of Nuclear Desalination (2000)** • **TECDOC – Examining the economics of seawater desalination using the DEEP code (2000)** • **TECDOC – Floating nuclear energy plants for seawater desalination (1997)** • **TECDOC – Use of nuclear reactors for seawater desalination (1990)**
Tools&Toolkits	Identification of cost options for desalted water and/or power • **DEEP (Desalination Economic Evaluation Programme)** Identification of water needs in NPPs, and comparative assessment of various cooling systems) • **WAMP (WAter Management Programme)** Links to IAEA related activities • **Nuclear Desalination Toolkit (a new version is to be released)**
R&D	Coordinated Research Projects (completed) • **Optimization of the Coupling of Nuclear Reactors and Desalination Systems** • **Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies** • **New Technologies for Seawater Desalination using Nuclear Energy** • **Application of advanced low temperature desalination systems to support NPPs and non-electric applications**
Events	• **Consultancy Meeting on developing plans for producing potable water using SMRs (Apr 27th, 2022)** Upcoming: • **Meeting of the Technical Working Group on Nuclear Desalination (TWG-ND) (6-8 September 2022)**
In progress	• **Plan for producing potable water economically using small and medium-sized nuclear reactors (IAEA GC65 Resolution)**

IAEA hydrogen-related resources

- IAEA hydrogen webpage: https://www.iaea.org/topics/non-electric-applications/nuclear-hydrogen-production
- Overall objective: support Member States in assessing options for hydrogen production using nuclear energy.
- Codes (HEEP, HydCalc, FRAMES);
- Hydrogen Toolkit;
- Publications;
- Meetings and events;
- Research and Development (CRPs).



IAEA hydrogen-related meetings and events

- IAEA GC65 side event:
  Innovations in the Production and Use of Nuclear Hydrogen for a Clean Energy Transition,
  September 21, 2021.

- *3rd Research Coordination Meeting on Assessing Technical and Economic Aspects of Nuclear Hydrogen Production for Near Term Deployment,*
  15-17 November 2021.

- *Technical Meeting on Assessing Technologies that Enable Nuclear Power to Produce Hydrogen*, 7–9 Dec 2020.

- *Technical Meeting on the Role of Nuclear Hydrogen Production in a Low Carbon Economy*, Apr 8-10 2019.

- TM *"Developing a Roadmap for the Commercial Deployment of Nuclear Hydrogen Production"*
  (jointly organized with PESS, April 5-7), to be followed by a CM on 8-10 June, 2022.

Upcoming

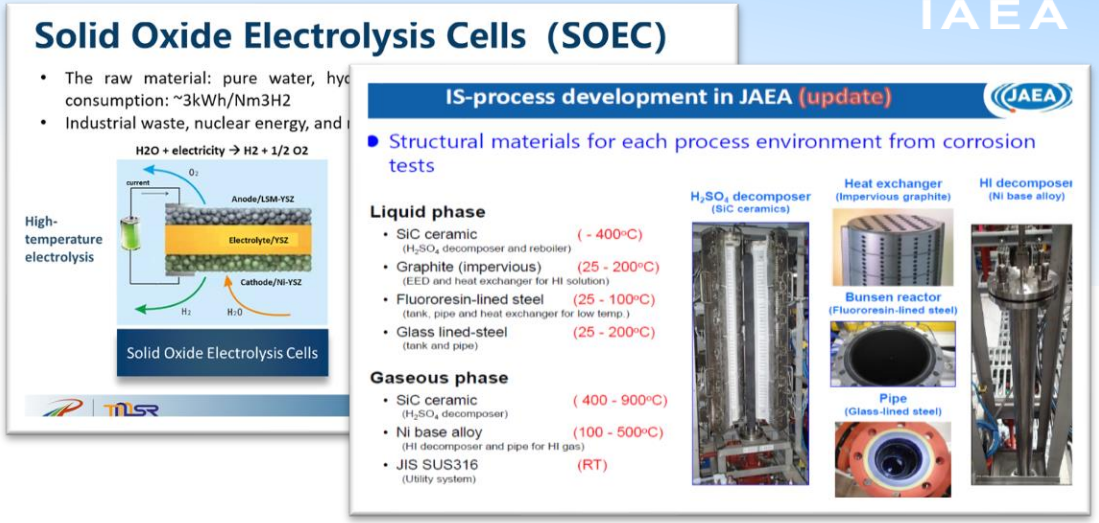
- International Workshop on the Role of Low Carbon Hydrogen for a Net Zero Energy System – June 22-24, Aix-en-Provence, France, IAEA + CEA + IEA, PESS + NPTDS.

- World Energy Hydrogen Conference (WHEC) - International Hydrogen Energy Association + Ontario Tech University organize the conference in cooperation with the IAEA - Istanbul, Turkey, 26-30 June, 2022.

IAEA hydrogen-related R&D (Coordinated Research Projects)

- Coordinated Research Projects (CRP 2018-2022):

  “Assessing Technical and Economic Aspects of Nuclear Hydrogen Production for Near-Term Deployment”.



Upcoming

- New CRP (2022-2026): “*Role of Nuclear Cogeneration for sustainable development*”

For nuclear cogeneration, with a focus on advanced nuclear hydrogen production, on advanced desalination using nuclear energy, district heating and industrial uses:

– Development of approaches, case studies, and supporting data for techno-economics assessment;

– Identification and development of technological aspects and advances to increased competitiveness;

– Quantify benefits of nuclear waste heat utilization on the water impact of nuclear installations and resulting environmental benefits for water bodies and climate change;

– Identification of risk factors, uncertainties and best practices in nuclear cogeneration projects to guide Member States' informed decision on the deployment of such projects.

IAEA hydrogen-related publications

- TECDOC - *Hydrogen as an Energy Carrier and its production by Nuclear Power,* (1999)
- NES - *Hydrogen Production using Nuclear Power,* (2012)
- TECDOC - *Examining the Techno-economics of Nuclear Hydrogen Production and Benchmark Analysis of the IAEA HEEP Software* (2018).

Upcoming

- TECDOC - *Outcomes of the CRP Assessing Technical and Economic Aspects of Nuclear Hydrogen Production for Near-Term Deployment*.
- NES - *Nuclear cogeneration towards climate change mitigation and sustainable development goals*.
- NES - *Vendor and user requirements and responsibilities in nuclear cogeneration projects*.
- NES - *Roadmap for the Commercial Deployment of Nuclear Hydrogen Production*, Summarizing the results of the corresponding TM & CM.

IAEA hydrogen-related tools and toolkits

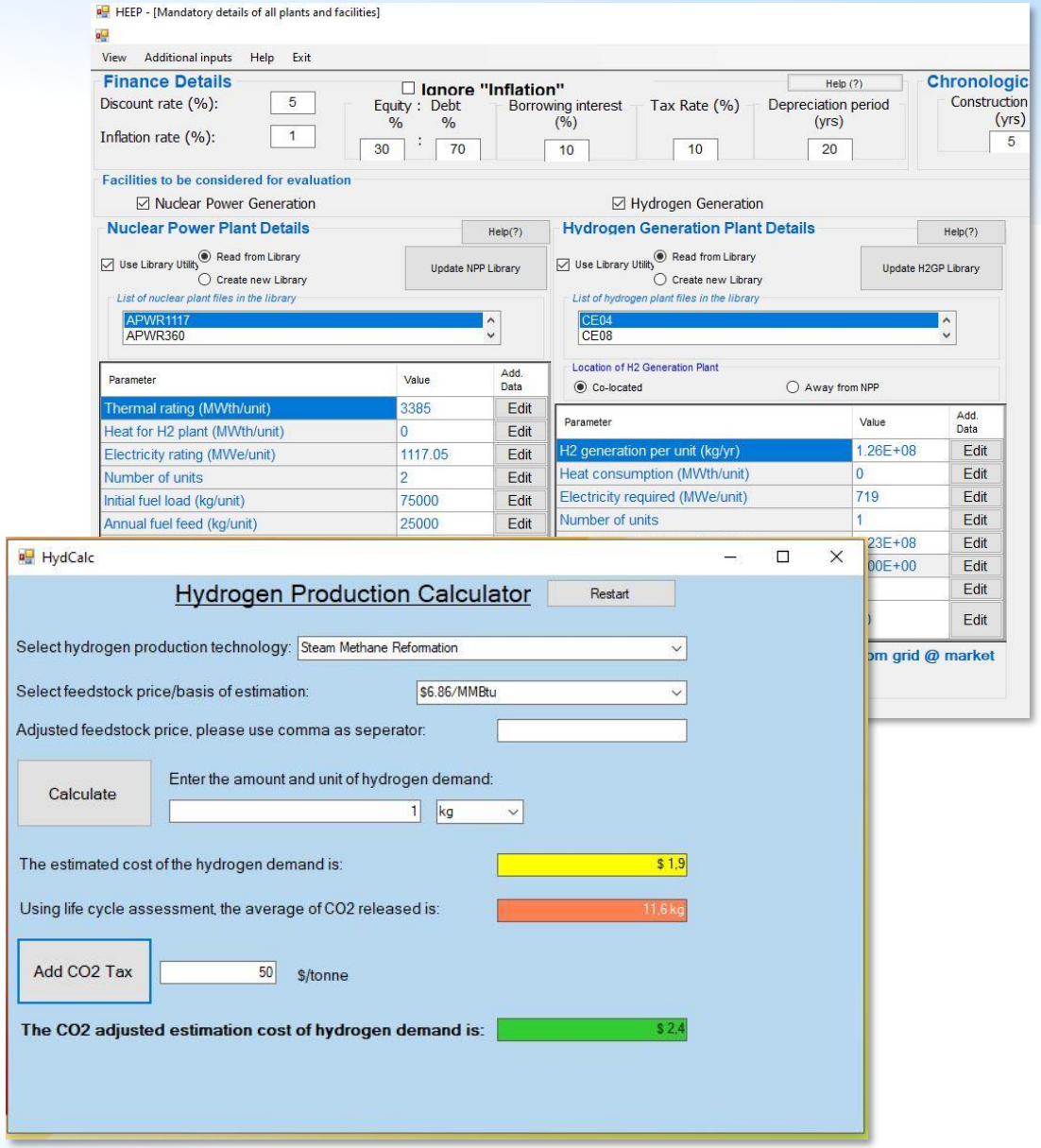
- HEEP: Techno-economic assessments of hydrogen generation options.

  New version released on the IAEA website since Nov 2021 (improved GUI and sensitivities studies)
  https://www.iaea.org/sites/default/files/22/01/2021-11-21_setup_heep.zip

- HydCalc: Hydrogen production cost calculator with nuclear and other technologies.
  https://www.iaea.org/sites/default/files/18/07/hydcalc.zip

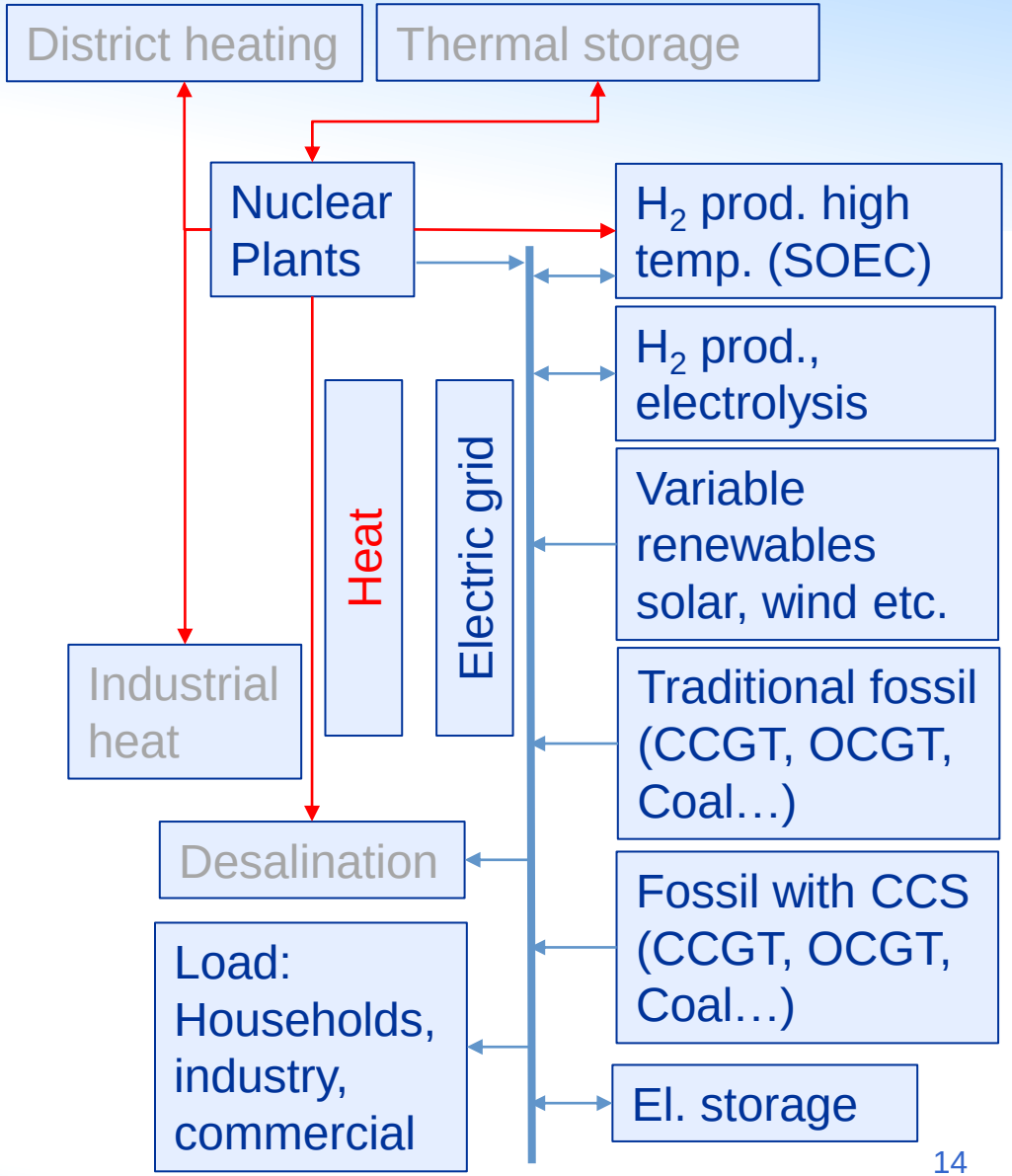
- Toolkit on nuclear hydrogen.
  https://www.iaea.org/sites/default/files/20/04/nuchydtoolkit.zip

- FRAMES: Integrated assessment of energy systems, including for H_2 production.



FRAMES: purpose/status/planned extensions

- Growing interest in integrated energy systems (Member States and IAEA), in particular with nuclear & renewables and with Non-Electric Applications
- IAEA is developing an in-house capability (FRAMES)
- Can quantify the value that nuclear brings to integrated systems, and inform policy
- Complete H_2 model, with 4 production methods.
- Other non-electric applications (desalination, thermal storage, district heating, industrial heat, etc.) on the drawing board.
- FRAMES is well suited to quantify the synergisms of non-electric applications and nuclear energy.

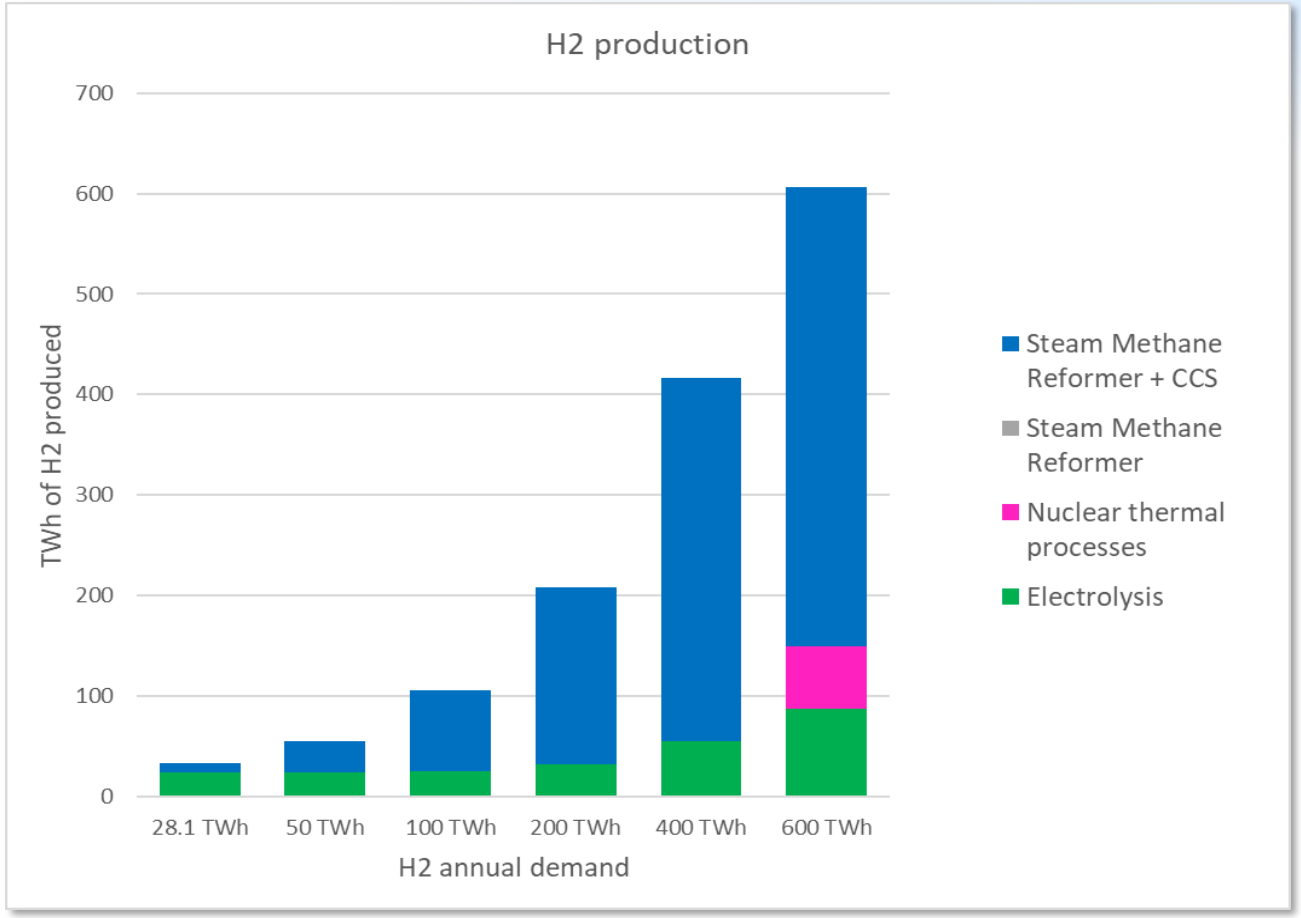


Four H_2 production options in FRAMES

- Conventional steam methane reforming (SMR) of natural gas;
- Steam methane reforming of natural gas with CCS (i.e. blue hydrogen);
- Low temperature electrolysis using grid electricity (PEM or Alkaline);
- High temperature processes using nuclear heat. It can be thermochemical cycles (e.g. S-I, Cu-Cl etc.) or high temperature steam electrolysis (HTSE).

FRAMES allows to study the relative competitiveness of the four processes under different sets of assumptions: CO_2 emission limits, costs of the various technologies, etc.

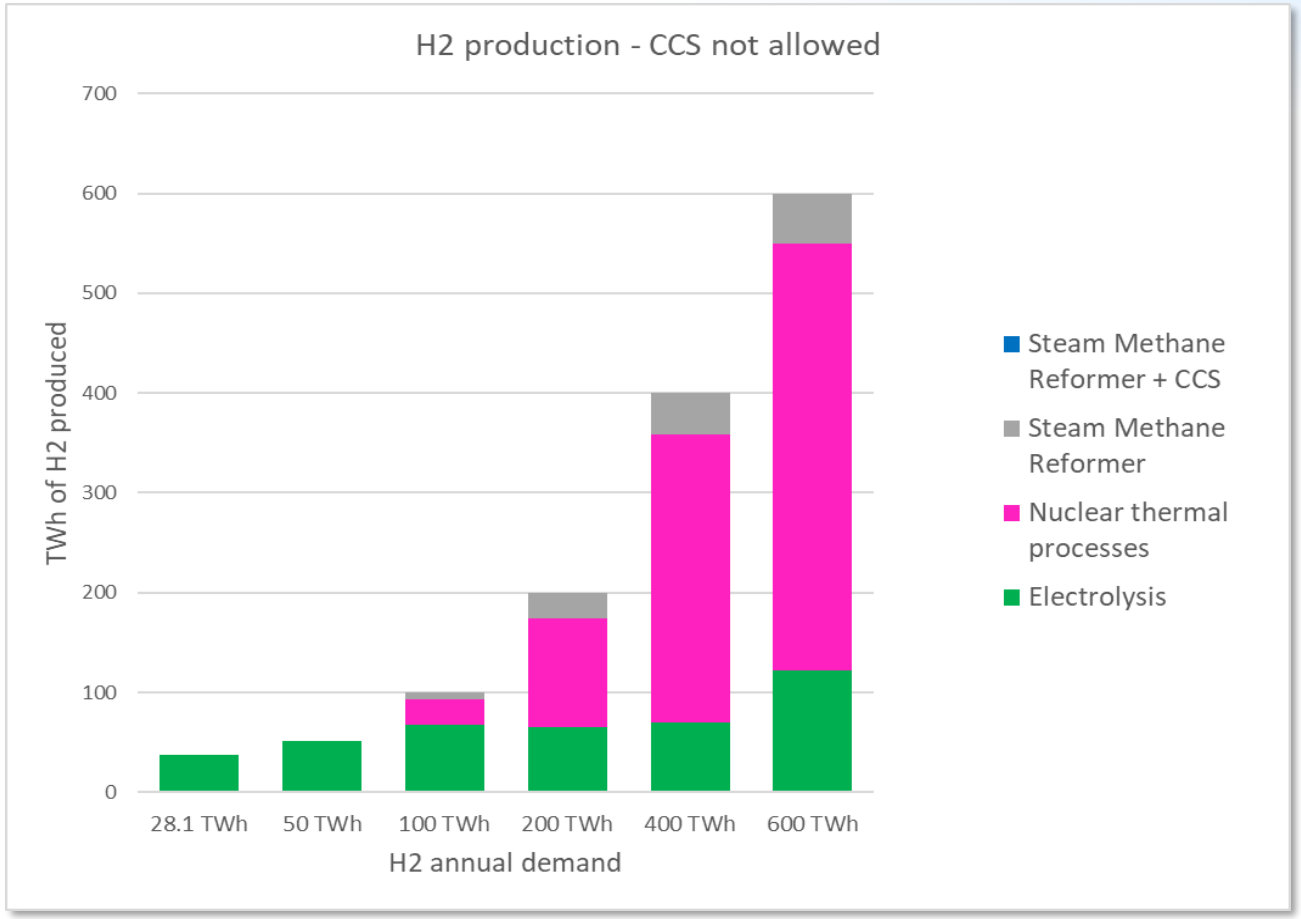
Steam methane reforming with CCS plays the leading role in producing large amounts of H_2



The high level of SMR deployment depends on some key assumptions:

- Fugitive CH_4 emissions from SMR+CCS have not been considered.
- High CO_2 capture rate (90%)
- Natural gas price (~$6/MMBTU).

In the absence of CCS, nuclear plays the leading role in producing low-carbon H_2 through the use of nuclear heat



These results depend on the relative cost of the various low-carbon technologies.

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8 December 1953


1 to 23 October 1957


11 December 1957


1959


10 December 2005

1958 to 1979


23 August 1979

Thank you for your attention!

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