State of play of the Euratom funded research on Small Modular Reactors (SMRs)

Second Meeting of the IAEA Technical Working Group for Small and Medium-sized or Modular Reactor (TWG-SMR)

European Commission (EC)
DG Research and Innovation
Foivos MARIAS
Policy/Project Officer
Foivos.marias@ec.Europa.eu

8 – 11 July 2019, Vienna

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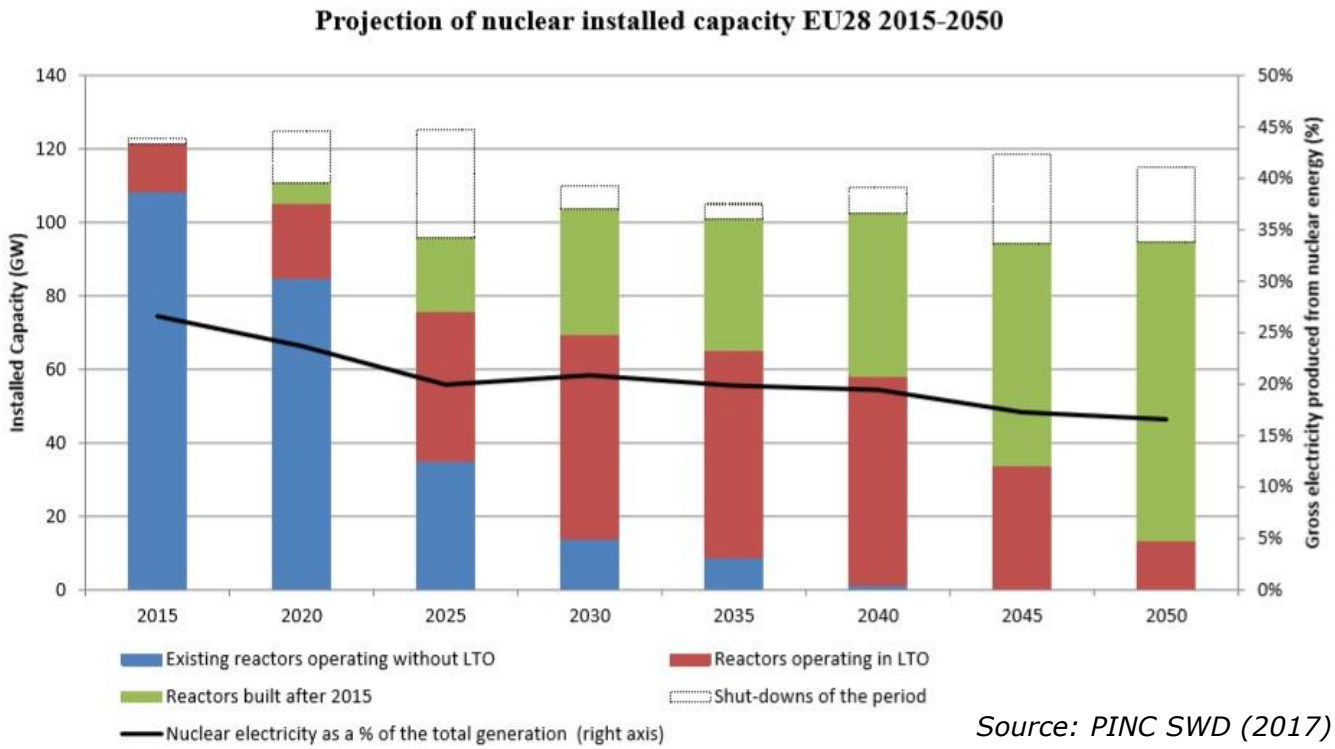
- *Nuclear Energy in the EU (PINC, « 2050 long-term strategy »)*
  - *The SMRs option.*
- *Euratom Research and Training (R&T) Programme*
  - *Activities on SMRs.*
  - *Euratom funded projects.*
  - *SMRs in the Work Programme (WP) 2019-2020.*
- *Horizon Europe (H-E) and H-E Euratom R&T Programme*

Nuclear Energy in the EU

European Commission

- *Nuclear Illustrative Programme (PINC)*
  - Share of nuclear from around 26% to around 17%.
  - Total installed capacity from around 120 GW to around 100 GW.



Source: PINC SWD (2017)

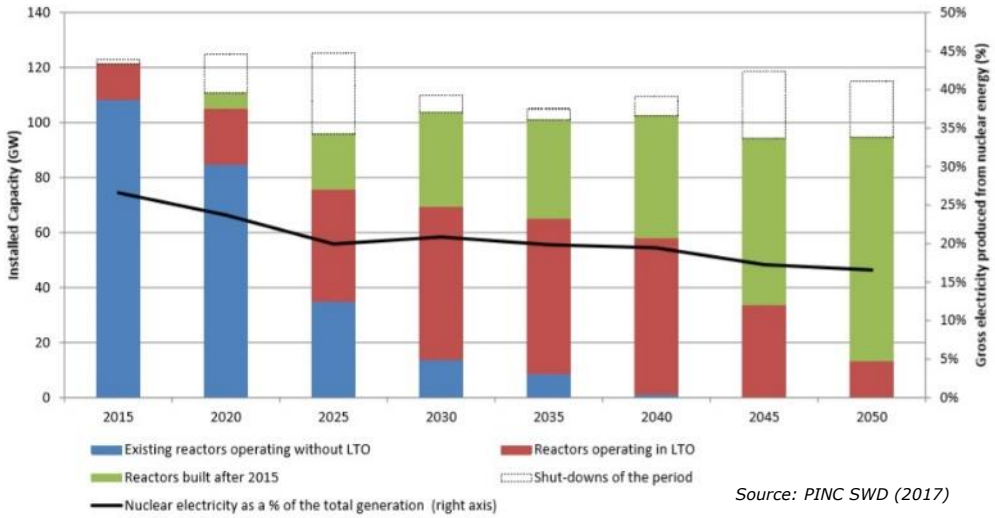
Nuclear Energy in the EU

- *Nuclear Illustrative Programme (PINC)*
  - Corresponding investments.

Projected investments in new nuclear capacity *Source: PINC SWD (2017)*

(EUR billion)	2015-2030	2031-2040	2041-2050	Total
Investments in new capacity	152 – 207	42 – 55	142 - 177	**336 - 439**
Replacement of shut-downs post 2050 (note A)	-	-	13 - 17	**13 - 17**
Total	**152 – 207**	**42 – 55**	**155 – 194**	**349 - 456**

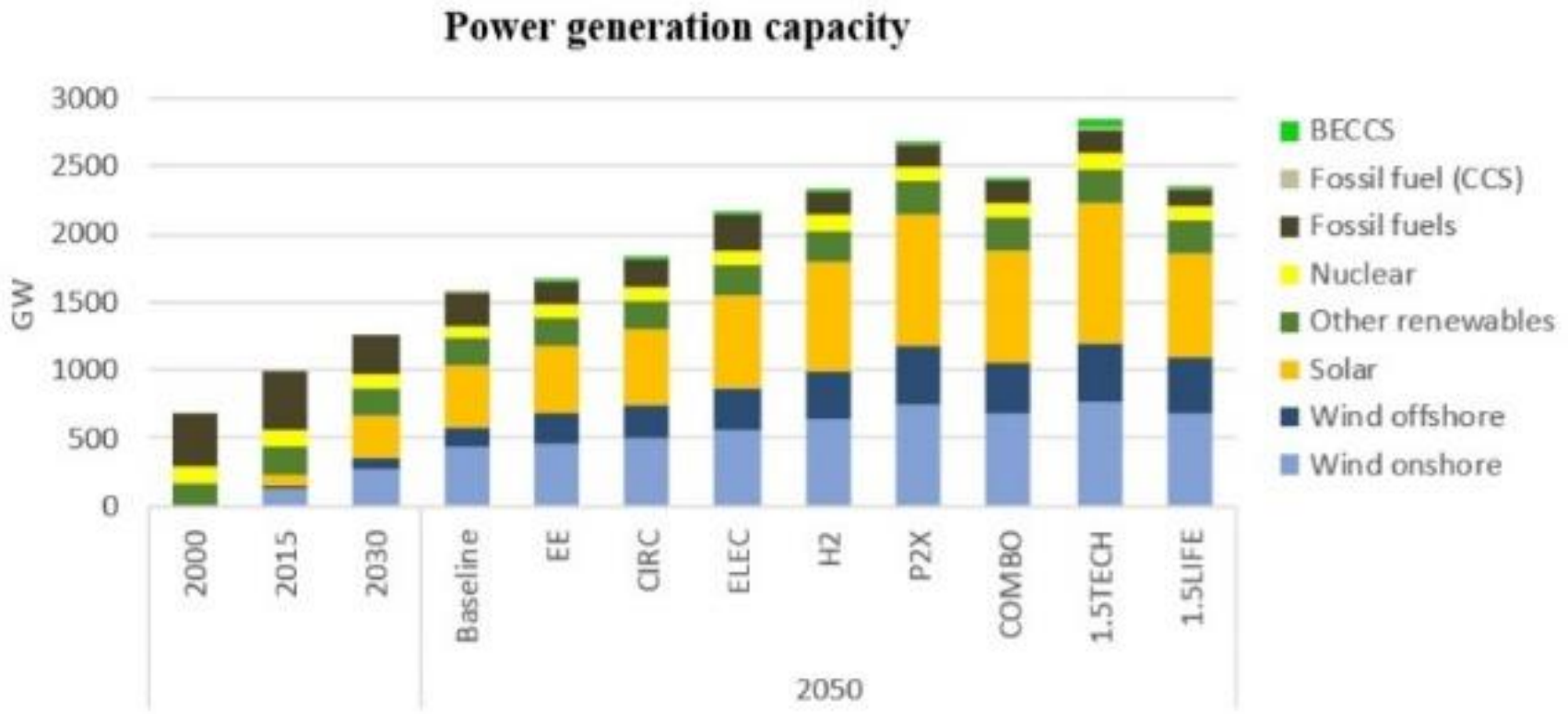
Projection of nuclear installed capacity EU28 2015-2050



Source: PINC SWD (2017)

Nuclear Energy in the EU

- *« 2050 long-term strategy » (climate-neutral Europe by 2050)*

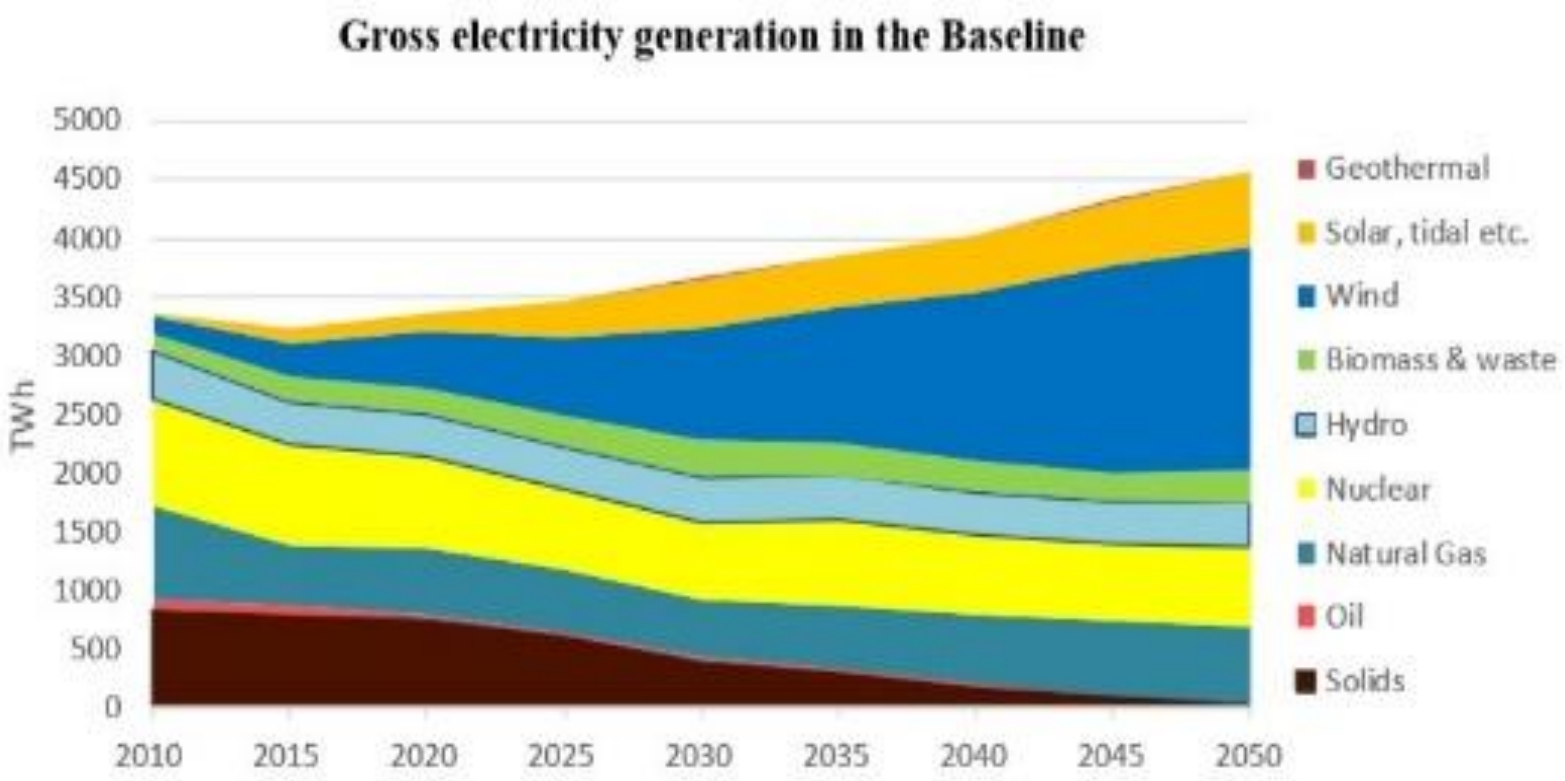


Research and Innovation

Sources: A clean planet for all, Eurostat, PRIMES

Nuclear Energy in the EU

- *« 2050 long-term strategy » (climate-neutral Europe by 2050)*



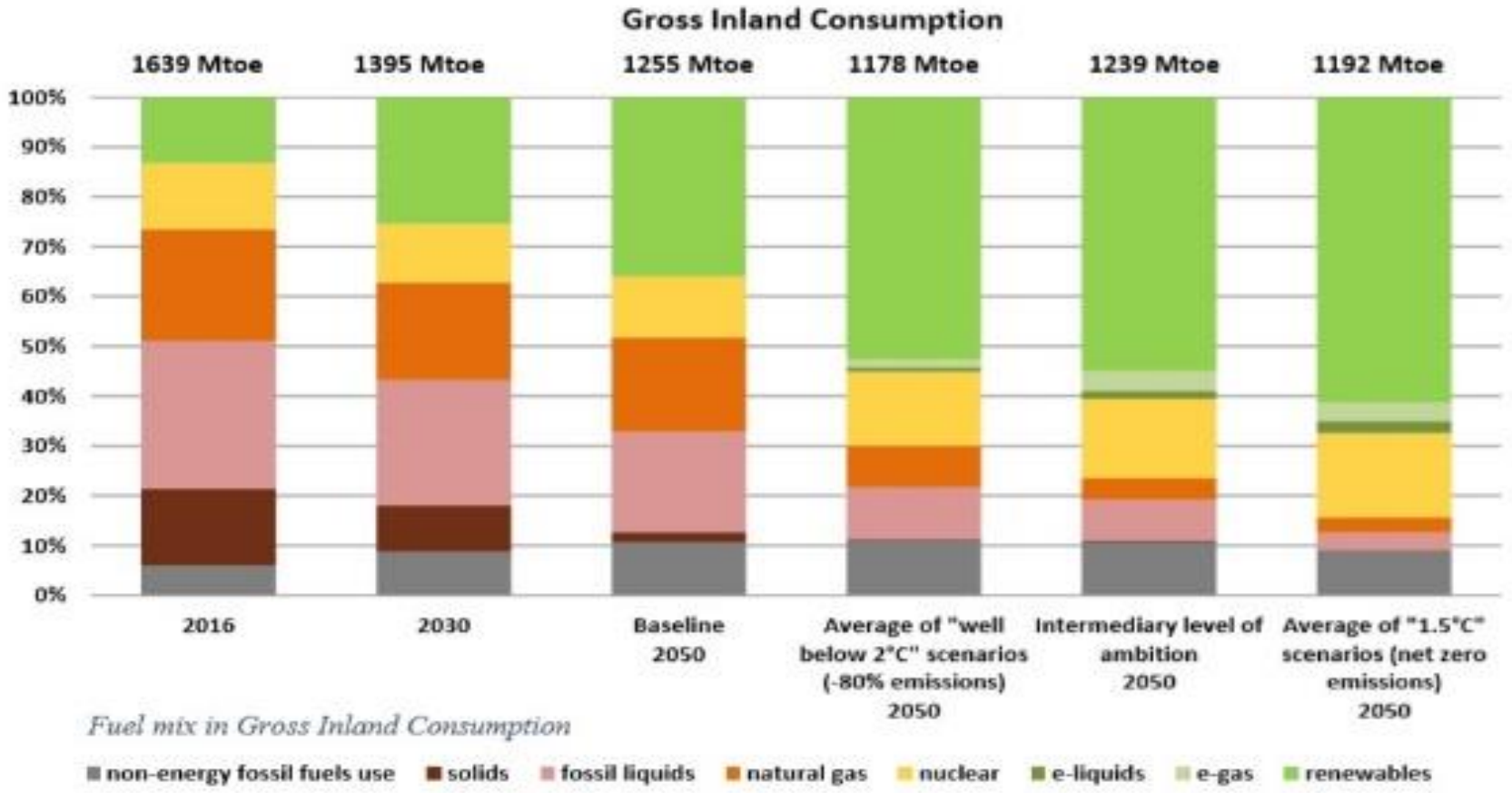
Research and Innovation

Sources: A clean planet for all, Eurostat, PRIMES

Nuclear Energy in the EU

European Commission

- *« 2050 long-term strategy » (climate-neutral Europe by 2050)*

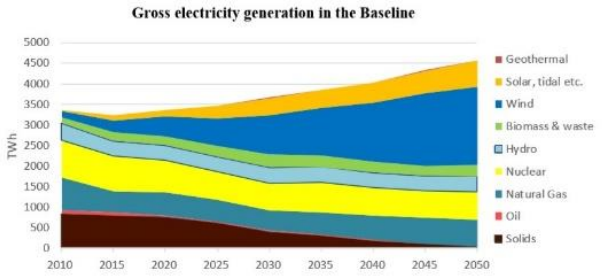


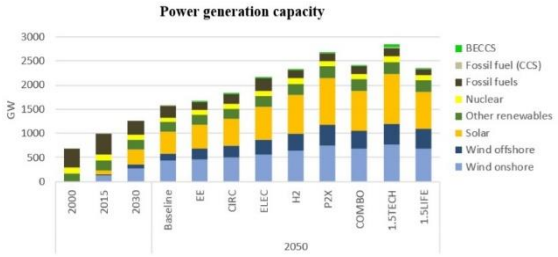
Research and Innovation

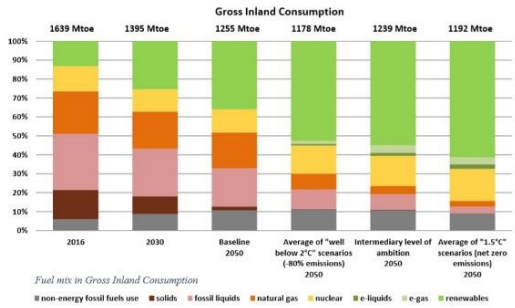
Sources: A clean planet for all, Eurostat, PRIMES

Nuclear Energy in the EU

- *« 2050 long-term strategy » (climate-neutral Europe by 2050)*
  - Power is nearly decarbonized by 2050.
  - Nuclear still plays a role in the power sector.
  - Renewable energy sources together with nuclear power "will be the backbone" of a carbon-free European power system.







Sources: A clean planet for all, Eurostat, PRIMES

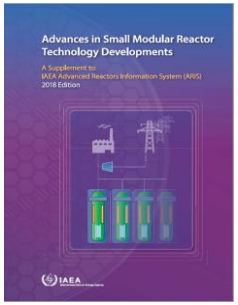
Nuclear Energy in the EU – The SMR option

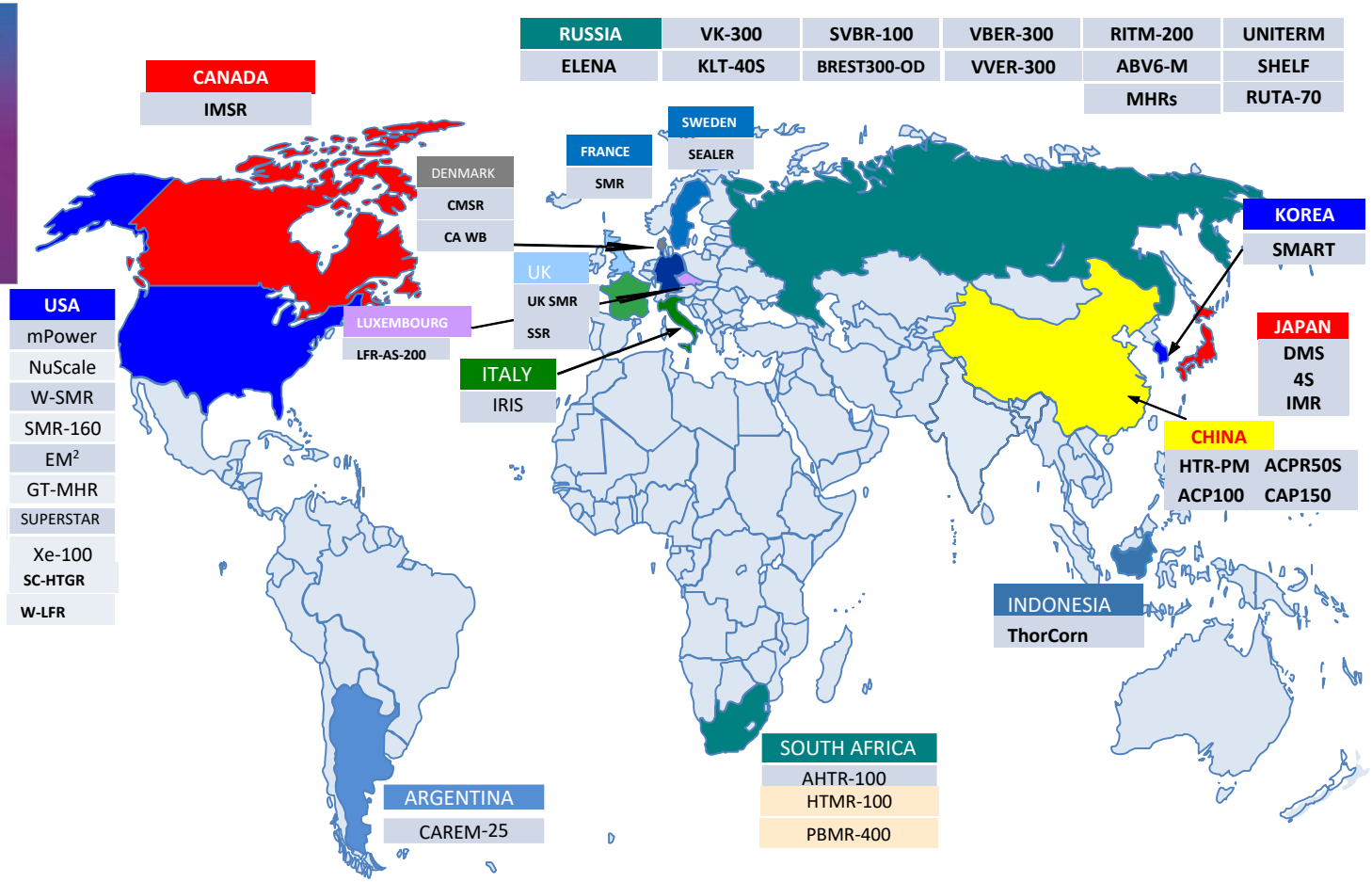
- *PINC*
  - One chapter of the SWD.
  - Overview of most advanced projects in the world.
  - Some elements about: the design, some SMR characteristics (e.g. integrated design, load-following capacity, power generation, cogeneration, economics, … etc.), safety and licensing, cost of decommissioning and waste management.
  - "The absence of a licensed SMR design in the market is a major challenge".

- *« 2050 long-term strategy »*
  - Flexibility in electricity generation from nuclear can be enhanced by the development of small modular reactors (SMRs).

European Commission

SMR Technology Development





Research and Innovation

Source: Monti (2019)

Nuclear Energy in the EU – The SMR option

European Commission

- *SMR projects in Europe according to IAEA*
  - 1 UK (LWR), 1 SE (lead cooled fast reactor), 2 LU (in cooperation with ENEA IT, Liquid metal cooled fast reactor), 2 DK (molten salt), 1 "International" (around IT entities, LWR).
- *Additional Euratom funded projects*
  - GEMINI plus (Euratom funded).
  - ELSMOR (Euratom funded).
- *National policies/strategies/approach on SMRs*
  - UK: targeted policy.
  - FR: Nuclear Industry strategic contract (focus 3: developing an SMR).
  - Finland: discussion on possible use for power generation and district heating.
  - EE: an undertaking launched a feasibility study.
  - UA: Energoatom, SSTC and Holtec created a consortium.

European Commission

EURATOM RESEARCH AND TRAINING (R&T) PROGRAMME 2014-2018 and 2019 - 2020

General Objective of the Euratom Programme:

- to pursue nuclear research and training activities with an emphasis on **continuous improvement of nuclear safety, security and radiation protection**, notably to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way.

European Commission

COUNCIL REGULATION (EURATOM)

The Euratom Programme indirect actions shall have the following specific objectives:

(a) supporting safety of nuclear systems;
(b) contributing to the development of safe, longer term solutions for the management of ultimate nuclear waste, including final geological disposal as well as partitioning and transmutation;
(c) supporting the development and sustainability of nuclear expertise and excellence in the Union;
(d) supporting radiation protection and development of medical applications of radiation, including, inter alia, the secure and safe supply and use of radioisotopes;
(e) moving towards demonstration of feasibility of fusion as a power source by exploiting existing and future fusion facilities;
(f) laying the foundations for future fusion power plants by developing materials, technologies and conceptual design;
(g) promoting innovation and industrial competitiveness;
(h) ensuring availability and use of research infrastructures of pan-European relevance.

Euratom R&T Programme and SMRs

- *WP 2014-2015*
  - No dedicated SMR topic.
  - 3 unsuccessful SMR proposals submitted / 1 LWR (Light Water Reactor), 1 Lead-cooled reactor, 1 micro-reactor for space applications.
- *WP (Work Programme) 2016-2017*
  - Dedicated technology neutral SMR topic. Open to all applications.
  - 7 proposals submitted / 2 LWR, 1 on High Temperature Gas Reactor (HTGR), 2 Lead-cooled reactors, 1 on super-critical water reactor cooled system and 1 on cross-cutting aspects.
  - 4 M € / 1 successful project ("GEMINI plus" a HTGR for cogeneration).
- *WP 2018*
  - Dedicated LWR SMR topic. Open to all applications.
  - 1 proposals submitted / LWR.
  - 3.5 M € / 1 successful project ("ELSMOR" a LWR for power generation).
- *WP 2019-2020*
  - Dedicated technology neutral SMR topic. Open to all applications.
  - 8 M € / 2 expected successful projects.
- *In total for 2016-2020*
  - 4 SMR projects (1 HTGR for cogeneration, 1 LWR for power generation and 2 to come).
  - € 15.5 million.

GEMINI+ project

European Commission

- *Coordinated by National Centre for Nuclear Research (NCBJ), Poland*
- *Budget: € 4 M*
- *Duration: 36 months*
- *Launched: Sept. 2017*
- *27 partners*
- *Universities, research organisations, SMEs, TSOs, industrial players*
- *INCO: US NGNP Industrial Alliance + JAEA Japan + KAERI Korea*
- *Euratom funded project*
- *HTGR SMR*

Source: Wrochna (2019)

- *Developing the design basis of a nuclear plant for process heat needs of Polish / European industry that can become competitive with fossil fuel-fired plants in the context of penalties on CO2 emissions, thanks to:*
  - Possible design simplifications due to small size.
  - Use of modular manufacturing and construction techniques.
  - Design standardisation in spite of versatile needs of industrial applications.

- *Proposing a licensing framework for such a nuclear system and its coupling with industrial process heat applications.*

- *Preparing a full scale demonstration (nuclear + coupling with industrial processes) in Poland.*

Source: Hittner, Wrochna (2019)

GEMINI+ project: Work Packages (WP)

Euratom R&T Programme and SMRs

WP1 – safety

A licensing framework for the development of a new nuclear cogeneration modular HTGR, addressing recent safety requirements (EU nuclear safety directives etc.).

WP2 – conceptual design

A reference HTGR configuration acceptable for licensing both in Europe and in the USA, with a future objective to develop this technology in other countries.

WP3 – innovations

A safe nuclear HTGR system compliant with the highest safety standards, able to provide energy to citizens and industry at a competitive cost.

WP4 – deployment

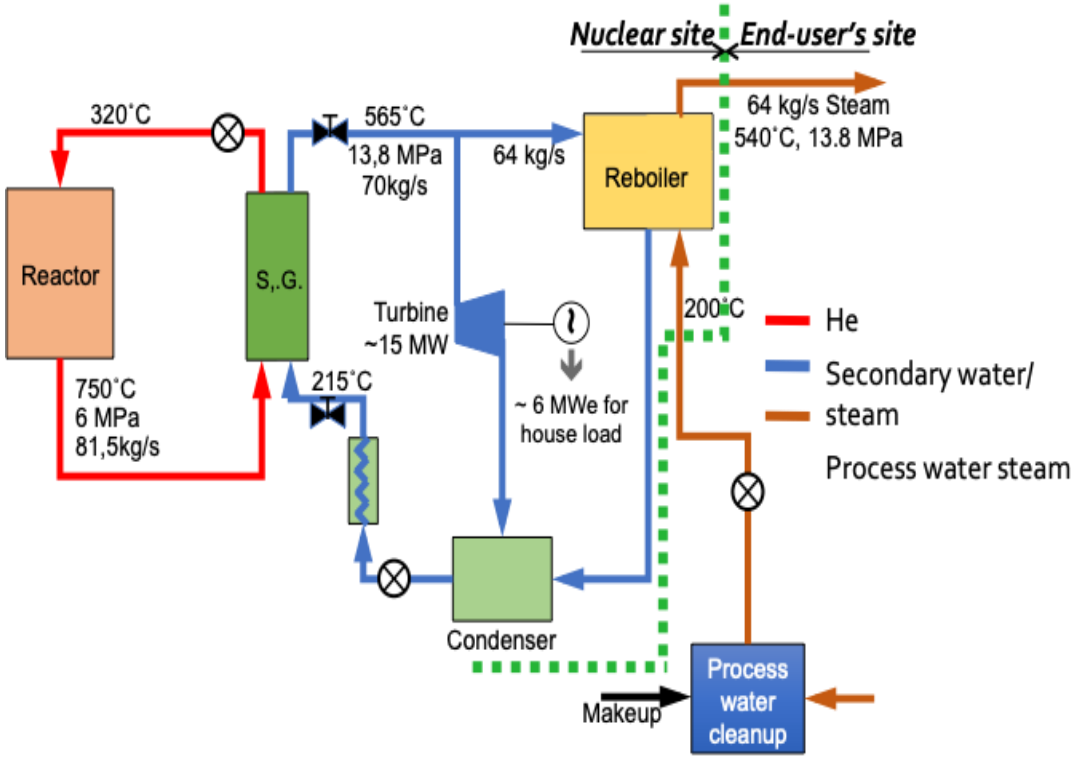
A plan for an industrial demonstration: acceptable site, appropriate funding and business schemes, industrial and technological readiness, ensuring supply chain for components, spent fuel management…

Source: Wrochna (2019)

- *Innovative safety approach:*
  - Explore unique HTGR safety features to reduce the cost.
  - Address the safety of the coupling reactor / industrial processes.
- *Breaking economy of the scale:*
  - Cogeneration (~80% use of energy).
  - Large market (PL: 10-20, EU: 100-200, world >1000).
  - SMR: factory fabrication of sub-systems with fast assembling on site.
- *Universality (Same design for different applications):*
  - Steam for chemical factory.
  - Cogeneration: turbines + various heat applications (district heating, industry).
  - Potential for CO2 free hydrogen production.
- *Separation from the user installations:*
  - No influence of user installations on the reactor.

Source: Wrochna (2019)

- Block type core (Higher power density (compactness).
- TRISO fuel.
- Cylindrical core design (compactness).
- A flexible nuclear boiler.
- Delivering only steam:
  the uses of steam
  (in industrial processes
  and/or in electricity generation)
  are outside of the nuclear system.
- Can be plugged into an existing industrial steam distribution network, substituting a fossil-fired boiler without any change in the existing infrastructure.
- With simple, robust and fully passive safety based on intrinsic properties of the reactor materials (conduction, radiative heat transfer) and on permanent natural circulation in the sole dedicated safety system, the Reactor Cavity Cooling System.
- All sub-systems (including the vessel) sufficiently compact to be transportable by road.



Source: Wrochna (2019) and Hittner, Wrochna (2019)

ELSMOR project

- *Coordinated by VTT, Finland (FI).*
- *Budget: € 3.5 M.*
- *Duration: 42 months.*
- *Launched: Sept. 2019.*
- *15 partners.*
- *Universities, research organisations, TSOs, industrial players.*
- *Euratom funded project.*
- *LWR SMR*

Partners

- *FI: VTT, FORTUM.*
- *FR: CEA, EDF, Framatome, IRSN, Technicatome.*
- *IT: CIRTEN, ENEA, SIET.*
- *DE: GRS.*
- *LT: LEI.*
- *UA: Energorisk.*
- *CH: PSI.*
- *JRC*

- *To identify and review the innovative safety features of LW-SMRs.*
- *To develop methodologies for robust safety assessment of LW-SMRs.*
- *To produce relevant experimental data and develop tools for science-based safety assessment of LW-SMRs.*
- *To demonstrate the usability of the tools developed in the project.*
- *Relevance of results to stakeholders and future impact on deployment of LW-SMRs.*

ELSMOR project: Work Packages (WP)

Euratom R&T Programme and SMRs

WP1

Identification of advanced or innovative safety features of LW-SMRs that potentially pose challenges to established safety demonstration approaches.

WP2

Developing methodologies with qualitative and quantitative recommendations to support the safety demonstration of the innovative features of LW-SMRs.

WP3 – focus heat exhangers

Focus on core cooling safety functions of integral LW-SMRs. Work to be performed is associated with safety analysis, development and assessment of codes and models, and specification of scaling or other requirements for tests and experiments to characterize the most promising passive systems.

WP4 – focus containment structure

development, assessment, and validation of analysis methods and tools for the safety demonstration of improved or innovative containment safety function features of integral LW-SMRs.

WP5

Application of methodology, safety approach and models for assessing passive safety systems to a specific design.

Euratom Work Programme 2019-2020

European Commission Implementing Decision C(2018) 8412 Adopted on 14.12.2018

Published on the 'Funding and Tenders' website:

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-search

European Commission

Call – Nuclear Fission & Radiation Protection Research NFRP 2019-20

A. NUCLEAR SAFETY
B. DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION
C. RADIOACTIVE WASTE MANAGEMENT
D. EDUCATION & TRAINING
E. RADIATION PROTECTION AND MEDICAL APPLICATIONS
F. RESEARCH INFRASTRUCTURE

European Commission

Research and Innovation Actions (RIA)

Topic	Budgets (EUR million)
Nuclear safety - NFRP-01: Ageing phenomena of components and structures and operational issues	16
Nuclear safety - NFRP-02: Safety assessments for LTO upgrades of Generation II and III reactors	12
Nuclear safety - NFRP-03: Safety margins determination for design basis-exceeding external hazards	8
Nuclear safety - NFRP-05: Support for safety research of Small Modular Reactors (SMRs)	8
Nuclear safety - NFRP-06: Safety Research and Innovation for advanced nuclear systems	7.6
Nuclear safety - NFRP-07: Safety Research and Innovation for Partitioning and/or Transmutation	6

NFRP-05: Support for safety research of Small Modular Reactors (SMRs)

Specific Challenge: SMRs are considered as a reasonable option to cover future energy needs. **Compliance with the safety objective as established by Article 8a** of the Nuclear Safety Directive may significantly vary depending on the safety options of the proposed design.

Scope: The research should **propose the methodologies for the performing safety evaluations and safety improvements** fostering safety standards, including the experimental validation of essential items for safety demonstrations.

Expected Impact: To **establish a baseline for safety assessments** and verification of existing SMR concepts during the following years.

Type of Action: Research and Innovation Action

Budget: 8 mil.

European Commission

WP 2019-2020 Calendar

WP Adoption:	*14 December 2018*
Call Open:	*15 May 2019*
Submission deadline:	*25 September 2019, 17.00.00 Brussels local time*
Evaluation:	*November 2019*
Info to the applicants:	*January–February 2020*
Signature of GAs:	*May 2020*

Further Information

Participant Portal

http://ec.europa.eu/research/participants/portal/desktop/en/home.html

Horizon 2020 Documents

http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html

Horizon 2020 On-line Manual

http://ec.europa.eu/research/participants/portal/desktop/en/funding/guide.html#

Questions? *Research Enquiry Service*

http://ec.europa.eu/research/enquiries

European Commission

Commission proposal for

Horizon Europe

THE NEXT EU RESEARCH & INNOVATION PROGRAMME (2021 – 2027)

(Under negotiation)

Research and Innovation

Horizon Europe

#HorizonEU

Horizon Europe is the Commission proposal for a € 100 billion research and innovation funding programme for seven years (2021-2027):

to strengthen the EU's scientific and technological bases

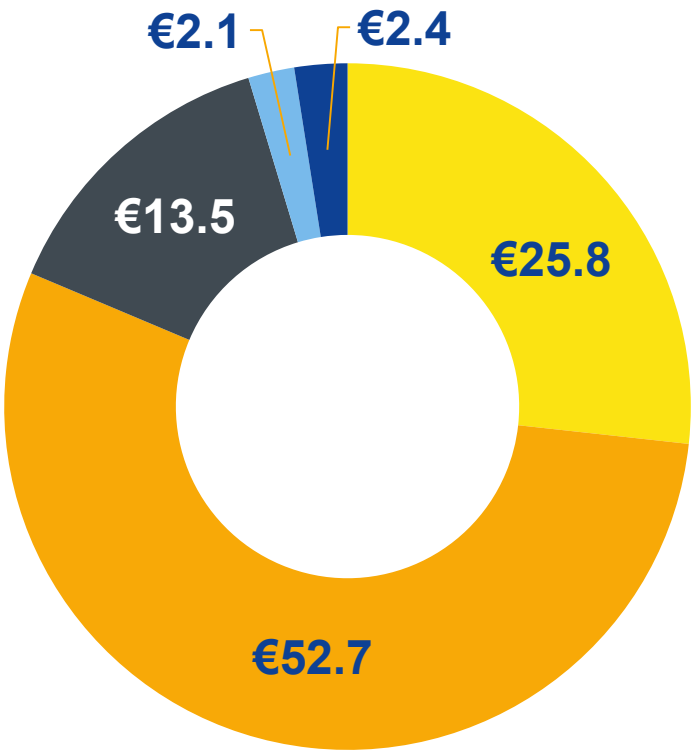
to boost Europe's innovation capacity, competitiveness and jobs

to deliver on citizens' priorities and sustain our socio-economic model and values

Horizon Europe

#HorizonEU

**€ 100 billion (bn) *
In current prices**



- Open Science
- Global Challenges & Ind. Competitiveness
- Open Innovation
- Strengthening ERA
- Euratom

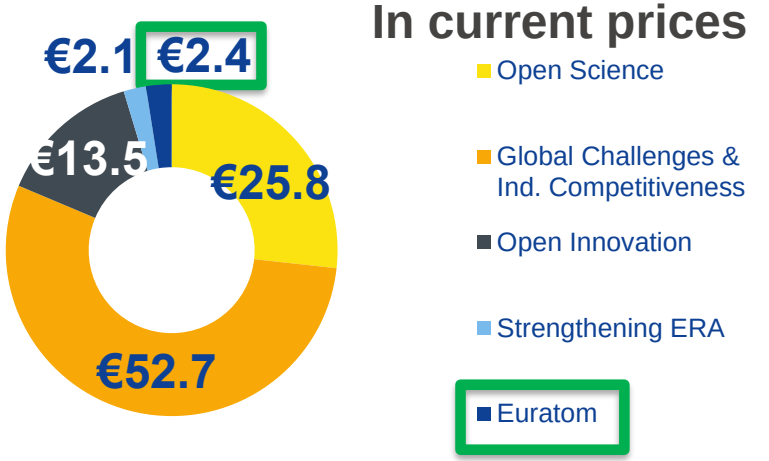
* This envelope includes EUR 3.5 billion allocated under the InvestEU Fund.
7-year programme

Research and Innovation

Horizon Europe

#HorizonEU

Euratom Research and Training (5 years € 1.675 bn)	
Indirect RTD	
• Fusion R&D	**EUR 724 million**
• Fission R&D Safety and radiation protection	**EUR 330 million**
Direct JRC	
• Fission Safety and safeguards	**EUR 620 million**
ITER 7 (years, a dedicated EC Decision)	
	EUR 6.1 billion



* This envelope includes EUR 3.5 billion allocated under the InvestEU Fund.
7-year programme

Research and Innovation

- *General objectives:*
  - (a) to pursue nuclear research and training activities to support continuous improvement of nuclear safety, security and radiation protection;
  - (b) to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way.

- *Specific objectives:*
  - (a) improve the safe and secure use of nuclear energy and non-power applications of ionizing radiation, including nuclear safety, security, safeguards, radiation protection, safe spent fuel and radioactive waste management and decommissioning;
  - (b) maintain and further develop expertise and competence in the Community;
  - (c) foster the development of fusion energy and contribute to the implementation of the fusion roadmap;
  - (d) support the policy of the Community on nuclear safety, safeguards and security.

- *Budget: € 1.675 billion (2021-2025)/€ 2.4 billion (2021-2027)*
  - For fusion (indirect actions): € 724 563 000 (without ITER)
  - For fission (indirect actions): € 330 930 000
  - For fission (JRC direct actions): € 619 507 000

- *Ongoing negotiation*

References

- *PINC SWD (2017), https://ec.europa.eu/energy/sites/ener/files/documents/pinc_staff_working_document_.pdf*
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- *Wrochna (2019), Presentation at FISA conference 2019.*
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THANK YOU FOR YOUR ATTENTION!

Contact information:

Mr. Foivos MARIAS
Policy/Project Officer
European Commission (EC)
DG Research & Innovation (RTD)
Directorate D - Clean Planet
D4.1- Euratom Research, International Cooperation (Euratom)

Tel: +32 2 29 87 344
email: foivos.marias@ec.europa.eu