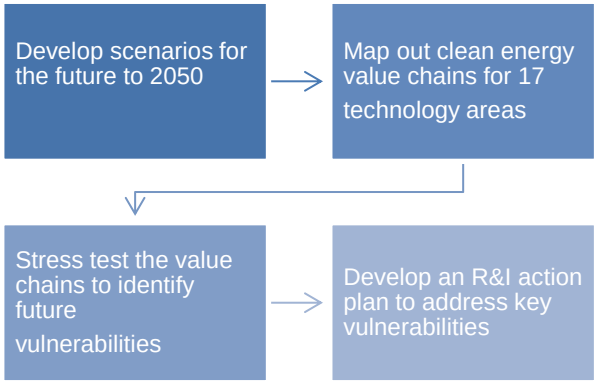
European Commission

How can we ensure energy security in Europe as we transition to clean energy?[1]

Through assessing the critical components of European clean energy technology[2] value chains now and towards 2030 and 2050, R&I opportunities have been identified in a study executed by a consortium between RAND Europe, CE Delft and E3-Modelling to address critical points in the value chains to strengthen European energy security.

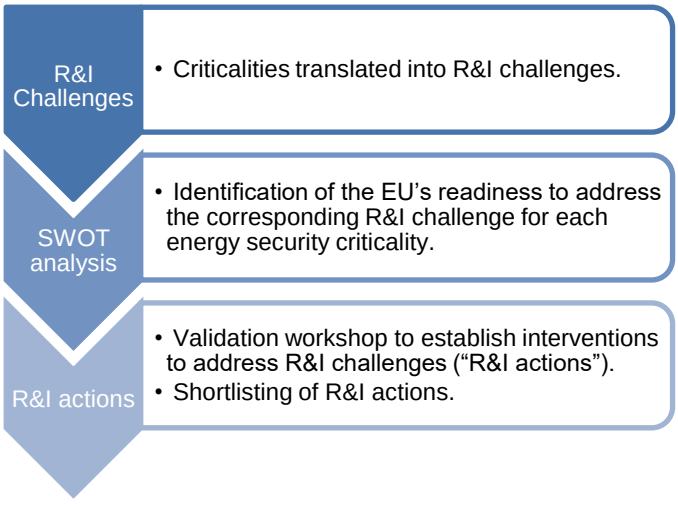


Methodological approach

Scenarios (Task 1). Development of scenarios served as a method to explore how political, social, economic, environmental, technological and legislative trends may influence EU clean energy security. Scenarios were developed by identifying systems (ScMI software), identifying drivers of change and projections. The scenarios development was complemented with corresponding macroeconomic and energy systems (GEM-E3) modelling. Three plausible future scenarios that provide challenges to future EU clean energy security were developed and used to assess stress on each energy security indicators.

10 Energy security indicators identified through PESTLE analysis: Geopolitical availability, abundance, circularity, supply chain complexity and location, digital and physical vulnerability, broader sustainability, affordability, skills.

Value Chain Assessment (Task 2). A short-list of criticalities was identified through assessment of technology value chains against the energy security indicators. The **R&I action Plan (Task 3)** task translated the criticalities into specific R&I interventions. The approach was validated in the **validation workshop** (**Task 4**).



[1] Commissioned under specific contract RTD/2022/SC/023 - Study on clean energy R&I opportunities to ensure European energy security by targeting challenges of distinct energy value chains for 2030 and beyond.

[2] **Technologies in scope:** Advanced Biofuels, Bioenergy, Concentrated Solar Energy, Geothermal Energy, Hydropower, Ocean Energy, Photovoltaics, Wind Energy, Direct Solar Fuels, Carbon capture Utilisation and Storage, Electricity and Heat Storage, including Batteries, Hydrogen and Intermediate Energy Carriers, Heat Pumps, Smart Energy Grid Technologies, Energy Building and District Heating Technologies, Off-Grid Energy Systems, Energy Transmission and Distribution Technologies, Smart Cities.

R&I Action Plan

In the table below, the top 9 highest-priority R&I actions, prioritised based on the SWOT analysis are presented. Full details on all 30 actions are provided in Section 10, including criticalities covered, expected outcome and scope (which criticality and value chain the action addresses), suggested Technology Readiness Level (TRL) by the end of the project and potential funding programmes.

Highest-priority energy security criticalities	R&I actions	Relevant value chain
Batteries *Supply chain location*	**Improving the energy efficiency of battery manufacturing and recycling** *Improving the energy efficiency of these processes would provide a mechanism to increase competitiveness for an EU-based supply chain; address currently missing capabilities, such as raw materials processing; and develop skills and know-how for an EU battery supply chain.*	Lithium-based batteries
CRM *Security of supply of CRMs*	**Research and public engagement on mining of CRMs** *Research and public engagement on mining of CRM would provide a better understanding of public concerns and mechanisms to address them (e.g. sustainable mining practices with minimal environmental impact, improved working conditions and operations). This will be important to enable domestic production to be increased, thereby derisking a range of clean energy technologies, and would inform both technical approaches and policy and regulation in this area, as well as international production to ensure consistent supply and imports from countries outside of the EU. This is a shared, international challenge requiring cooperation.*	Mining of all CRM, in particular: cadmium telluride and perovskite PV (supply of cadmium, telluride, copper, lead); batteries (cobalt, lithium); semiconductors and microchips in smart technologies, where public opposition is a risk within and out of the EU due to mining practices and environmental impact
Energy transmission and distribution technologies *Availability and abundance of CRMs (copper and aluminium)*	**Increasing circular economy processes, recycling and reuse of electronics for smart energy technologies** *R&I programme to increase recycling and reuse in energy transmission and distribution and develop the sustainable production of aluminium and other alternatives. The call would take a two-pronged approach, looking at opportunities to replace copper with aluminium more energy efficiently, and considering how to incorporate sustainable aluminium.*	HVDC cabling
Geothermal energy *Availability and abundance of CRMs (aluminium, copper, nickel, titanium, chromium)*	**Implementing a 'design to recycling' scheme for geothermal energy** *This Horizon Europe call would aim to implement a 'design to recycling' scheme, including reducing and reusing CRMs in geothermal energy.*	Construction phase of geothermal plants (CRM usage), end-of-life phase (all materials, including for casing and cementing)
Hydrogen *Supply chain resilience*	**A call for solutions to increase the resilience of hydrogen value chains** *With hydrogen technologies still in development, a call would support the development of solutions to increase the resilience of a future commercial value chain. This may include digital solutions, process efficiency improvements, reduced reliance on CRMs and water, design considerations for reduced complexity, and standard performance benchmarks.*	Solid oxide electrolysers (work at high temperature), electrodes and catalysts (CRM), and anion exchange membranes (AEM) (membrane component, water usage)

Compressed air energy storage (CAES) *Sustainability and environmental impacts*	**Developing a better understanding of the potential locations for underground CAES** *This research programme would aim to develop a better understanding of the potential locations for underground CAES. The extensive exploration for underground storage space adds considerable complexity to the construction and use of CAES, since CAES can only be deployed in areas where suitable underground cavities are available. The environmental risks of compressed air storage in depleted gas fields are relatively unknown and necessitate additional research. This could also ensure local social acceptance.*	Compressor and expansion system, above-ground storage tanks prior to injection, location of storage sites
PV *Supply chain location*	**Collaborative industry programme to increase the efficiency of PV manufacturing in the EU** *This Horizon Europe collaborative industry programme would support initial new supply chains focused on increasing the efficiency of solar PV manufacturing processes in the EU. This would support the development of solutions enabling onshoring and cost competitiveness of EU-based PV supply chains.*	Construction of silicon-based PV modules and CRM within modules
Smart energy grid technologies and energy building and district technologies *Digital vulnerability*	**Addressing cybersecurity risks to smart energy grid, building and district heating technologies** *This intervention would develop solutions to address cybersecurity risks, including research to ensure cybersecurity can be maintained for legacy systems. Understanding of the landscape of threats will help inform regulation and standards.*	Advanced meter infrastructure, advanced control technologies and home energy management systems
Smart energy grids, smart cities, and energy buildings and district heating technologies *Availability and abundance of CRMs and location of advanced electronics supply chains (palladium, cobalt, gallium, germanium, silicon, rare earth materials)*	**Increasing circular economy processes, recycling and reuse of electronics for smart energy technologies** *Recycling and reuse of electronics is currently low, and as early generation technologies reach end of life, there is an opportunity to support EU supply through recycling and reuse of these resources. This intervention would develop circular economy processes to increase the recycling and reuse of electronics for smart energy technologies. In particular, this should focus on the opportunities to reuse CRMs and will provide mechanisms to increase self-sufficiency within the EU.*	Construction and end-of-life phases in these technologies (less relevant for electric vehicle smart charging), including e-waste and cable waste, advanced metering infrastructure (which often incorporates semiconductors)

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