

ECOSENS – WorkPackage3 A System of Provision approach for nuclear power

SNETP Forum



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WP3 addresses key weaknesses in existing socio-economic models, broadening the scope of indicators to include various stakeholders, such as consumers, governments, and suppliers, rather than focusing solely on investors. Based on the System of Provision (SoP) approach, an approach to the study of consumption, this model identifies a set of determinants, preconditions, enablers and barriers from socio-economic, political, technological, socio-cultural and environmental perspectives. The object of investigation is not limited to a single power plant or the physical infrastructure but encompasses the entire nuclear Large Technological System (LTS).

Determinants	Preconditions	Enablers SOCIO-ECONOMIC	Barriers
Human Resources	Availability of human capital (technical expertise)	High-Quality Technical Universities (FR) / Public and Private investments in Education (DE, FR) / Creation of Employment Opportunities (UK)	Shortage of skilled professionals (UK)
Public Financial Resources	Long-term availability of high capital from public finances	Country GDP sufficient to generate (DE, UK, IT, FR) / Tax Revenue for public financing (DE, UK, IT, FR) / Government willing to support nuclear technologies through subsidies (DE, UK, FR)	Low electricity price (DE) / High cost of capital (UK)
Lenders and Private Investors support	Ensure bankability and willingness to invest	Public-private partnerships (DE) / Consortium (FR) / Energy-intensive industry willing to co-finance nuclear technologies (FR).	Liberalisation of the electricity market increasing investors risk-averse attitude (DE, UK)
Nuclear supply chain	Existing capabilities on nuclear technologies within the country / Existence of nuclear military industry	Willingness of the domestic industry to develop capabilities and invest on nuclear technologies / Access to industrial capabilities outside the country (UK, IT) / Connection with other countries that have a robust nuclear supply chain (UK, IT)	Major actors in nuclear energy sector withdrawing from the nuclear market (DE)
Ability to undertake major projects	Strong project management infrastructure and expertise	Positive track record in large-scale infrastructure projects (DE, FR) / Effective government intervention (FR)	Negative track record in large-scale infrastructure projects (Cost overruns / Public opposition / Delays) (UK, IT)
		POLITICAL Political consensus on the role of	
Political Support	Guarantee of long-term political support on nuclear investment decisions	nuclear technologies (UK, FR) / Political structure that minimizes parliamentary interference in energy decisions (UK, FR)	Parties' coalitions opposing nuclear (DE) / Influence of political interests on energy policy (Politicization) (DE, IT)
Political stability	Stable political environment (general, not directly related to nuclear)	Powerful and effective governmental institutions (UK, FR)	Frequent changes in leadership and government (DE)
Governmental leadership	Active and centralized involvement of the government over energy decisions	Direct control of the key actors (FR)/ Unified decision-making body (UK, FR)	Weak government control (DE, IT)/ Decision-making process inefficiencies (IT)
Commitment to energy independence and security	Existence of a strategic energy plan Long term commitment to nuclear	Long-term energy self-sufficiency planning (DE, UK, FR) / High imports dependence (DE, UK, IT, FR	
Long-term planning	technologies (e.g., do not plan for a single reactor, but for a program of power plants)	Centralised decision-making (FR)	Privatization (DE, UK)
Liberalized market	Well-functioning market mechanisms and regulatory frameworks that ensure fair competition among energy providers	Corporate investment and innovation drive, allowing for competitive pricing and technology advancement	Market volatility and corporate interests prioritize short-term profits over long-term national energy security or safety, (DE, UK
Centralised Governance	Strong state institutions capable of long-term planning and effective coordination	Centralised capabilities under a single entity (FR)	
	Existence of a national waste	TECHNOLOGICAL	
Radioactive Waste	repository in the country / Long- term agreements on waste management with other countries/ Existence of aradioactive waste management program and of a national radioactive waste organization	To have a nuclear industry with competencies in managing radioactive waste (FR)	Social opposition to the waste repository (IT) / Poor waste management (IT)
Electricity Demand	High electricity demand. Scale is not adequate: should have a neutral connotation	Electricity demand growth (DE, UK, IT, FR)/ Electricity export market available (FR)	Demand for energy coming from renewables (DE)
Standardisation of design	Commitment to a single nuclear technology/design	Centralised decision-making (i.e., single utility) (FR) Efficient construction methods and	Diversification (IT, UK)
Siting	Localised consumption centres	regulatory framework well- established (FR)	
R&D on nuclear technologies	High investment on R&D project on low TRL	Excellent technical universities (FR)/ Research centres (DE)	
Grid capacity	To have a reliable electricity grid	Grid centralised under the same utility (DE, FR)	Aging infrastructure (UK)
Primary energy sources	Scarcity of primary energy sources (e.g., coal, oil, methane, Hydro, wind)	Volatility price and uncertainty of alternatives (DE, UK, IT, FR) SOCIO-CULTURAL	Sunk costs and pathway dependency on long-term assets and investments for suppl of other energy sources (e.g., pipelines) (DE
Media Support	Dominant narrative favourable to nuclear technologies.	Transparent government communication (UK, FR)	Misinformation (IT)
Siting	Communities willing to host nuclear infrastructure	Job Opportunities in depressed areas (FR)	Local community opposition (UK, IT)
Citizens Support	High public acceptance of nuclear power (on average, considering different types of infrastructure)	Public trust in government actions (FR)/ Reframing of the technology (UK FR)	Anti-nuclear movements (DE)
Public awareness	Public knowledge on nuclear energy (awareness of pros and cons).	Educational campaigns (UK, FR) ENVIRONMENTAL	Low interest on the topic (DE, IT)
Environmental Sentiment	Positive nuclear environmental sentiment (e.g., no anti-nuclear environmental movements) .	Environmental reframing from the government (UK)	Environmental protest (DE)
Siting	Presence of suitable nuclear sites in the national territory (e.g., water availability, geological conditions).	Availability of water and lowly populated areas (DE, UK, FR)	
Circular Economy planning for reuse	Suitable dimensions of modules and components for transportation and inspection / Monitoring of modules and components' conditions	Early consideration of CE principles / Government support / Design standardization of modules components and interfaces	Modules and components contamination / Political pressure / Inappropriate regulator framework
1 0	The second secon	Stable electricity market prices /	

Method

Research Design: Multiple case study investigating the evolution of nuclear LTSs in France, Italy, Germany and United Kingdom.

Data Collection: Secondary data from scientific literature, national and international reports, Newspaper articles.

Data Analysis: Abductive thematic analysis leveraging the System of Provision approach.

Data Validation: Two workshops (one online and one in person) with international experts in nuclear technologies, social impacts, nuclear ethics, and radiation safety.

Findings

Nuclear LTSs developed and evolved in different ways in countries similar from demographic, economic, technological, and political perspectives.

External tipping points (e.g., oil crisis, Chernobyl accident, Fukushima accident) triggered different responses due to different determinants configurations.

The identified determinants are key not only in the development phase, but also to guarantee the continuation of the nuclear LTS.

Contributions

Understanding of dynamics of contrasting impacts in nuclear LTSs

Investigation of determinants supporting or opposing nuclear LTSs, and dynamic reconfigurations of such determinants

Development of a model based on such determinants for the assessment of the readiness level of a country in the development of the nuclear LTS and for the assessment of its resilience

Integration of dimensions broader than economic and financial indicators

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