NEEDS Database Report

Authors: Schenler W., Hirschberg S. and Burgherr P.

Contact: warren.schenler@psi.ch

(Please note that this report is only available in English)

1. Introduction

Within the EU Integrated Project NEEDS (New Energy Externalities Developments for Sustainability), the central objective of Research Stream RS2b "Energy Technology Roadmap and Stakeholder Perspectives" is to broaden the basis for decision support beyond the assessment of external costs and to extend the integration of the central analytical results generated by other Research Streams. The ultimate results of the technology roadmap will include mapping the sensitivity of sustainability performance of technological options to stakeholder preference profiles.

Two approaches will be used for the evaluation of the options. The first approach is based on total costs calculations (direct + external); estimation of total costs will be based on the information that is expected to be available from other research streams. The second approach will utilise Multi-Criteria Decision Analysis (MCDA), combining in a structured manner knowledge of specific attributes of the various technologies with stakeholder preferences.

The main efforts undertaken in RS2b concern the development of a framework for the implementation of MCDA. The approach is based on measuring the performance of competing technologies by different decision-making criteria. Performance for each criterion is judged by what may be called "indicators" or "measures" or "metrics." Such indicators may be either quantitative or qualitative. Quantitative measures can be ascertained with relative objectivity, given stated contributing assumptions. Qualitative measures must still be assigned a value for the multi-criteria assessment, but are based at least partially on subjective judgement. Each indicator attempts to quantify a certain aspect of a given criterion.

A fundamental part of such a framework is the establishment of a set of criteria and indicators to be used for the evaluation, and the creation of a database of indicators that actually embody the indicators that have been established. A separate report has provided an overview and description of the criteria set and associated indicators selected for use within NEEDS for the evaluation of electricity generating technologies and the associated fuel cycles. The present report describes how the indicators were collected from other Work Packages, completed with calculations within the present Work Package, combined into a database embodied in spreadsheet form and exported to the partner institution (IIASA) hosting the online web survey for the purpose of establishing stakeholder preferences.

The database includes 36 separate indicators for 26 future technologies (in the year 2050) in four countries, i.e. France, Germany, Italy and Switzerland.

The present report focuses on the process of combining and extending results obtained and documented in a number of Work Packages within RS2b, which in turn profited from a variety of experiences with criteria and indicators, accounted for in the literature. For the details we refer to the supporting RS2b publications; here the focus will be on presenting the requirements and process of creating the NEEDS sustainability database for future generating technologies.

Section 2 of this report describes the database requirements. Section 3 discusses the structure of the database, the data collected from contributors, the assumptions calculations necessary to extend the database to complete the full set of indicators, and the process of exporting data for the online survey of stakeholder preferences. Section 4 contains summary remarks and conclusions, and the Appendices contain tables and figures presenting the contents of the database for the four countries.

2. Database Requirements

The database draws together data on a wide range of future electricity generation technologies, including fossil technologies (coal, lignite and natural gas), nuclear technologies (pressurized water and breeder reactors), and a range of renewable resources (biomass, solar and wind). The 36 indicators cover a wide range of concerns in the three major areas of sustainability - the environment, the economy and society overall. The database that contains this wide range of information has a number of functional and practical requirements.

Functionality: The functional requirements of the database include the following;

- *Complete:* It is of course rather trivial to state that the database needs to include all the indicators contained within the criteria hierarchy developed for NEEDS. However, the data delivered from the various technical contributors did not contain all or exactly the same indicators as called for. In particular, a number of economic indicators were calculated and several social indicators adjusted for use in the final database. Developing or adjusting these indicators could technically be regarded as part of parallel work packages performed by PSI, but in practical terms these efforts were highly integrated with the database development.
- *Differentiated:* The database includes data for four different countries, and these countries differ in a number of ways. These differences include technology (or resource) availability, variations in operating conditions, and general or site-specific differences in impacts on the surrounding environment. These differences are discussed more specifically in Section 3 below.

- *Comprehensible:* The database must be structured so that it will be easy to understand and use, particularly as it will also be available as a stand-alone reference product of the NEEDS project.
- *Flexible:* It is a functional requirement of the database that it should be easy to update to reflect ongoing changes in database values, due to either updated contributions or error corrections. This means that the database will be easy to update in the future, but it is also true that the database should be lockable, so that it may only be updated by authorized users.

Practicality: In order to implement the functional requirements above, it is useful to translate them into some related practical requirements;

- *Editable:* The data in the database must be easily edited, but each datum should only need to be changed in one location.
- *Linked:* The data supplied by contributors to the database is usually delivered in the form of Excel spreadsheets. These should be linked to the database in order to make the transfer of data easier, reduce the chance of introducing errors, and facilitate updates.
- *Data Export:* The contents of the database must be easily exportable to the text files used as inputs to the online survey of stakeholder preferences.
- *Graphs:* As graphs of the individual indicators are by far the easiest way to present and understand the contents of the database, the database should automatically generate new graphs whenever the contents of the database are updated.

In practice, these requirements influenced the decision to structure the database in the form of a spreadsheet with multiple pages or worksheets. This choice was also supported by two factors related to the problem description;

- *Size*: The database size is relatively modest size (4 countries x 26 technologies x 36 indicators = 3744 individual entries), and
- *Use*: The primary use of the data is simply to be exported for use in the multi-criteria analysis, rather than being directly searched or analyzed.

Both of these factors meant that there was relatively little benefit to using specific, specialized database software. The spreadsheet format also addressed specific requirements in the following ways;

- *Linking:* By linking the data automatically from the relevant cells in the source sheets to cells in the database, it is possible to easily update the database (as long the format of the source spreadsheets remains constant). Within the database spreadsheet, indicators that are constant for all countries are contained in a master, generic country worksheet that is linked to four separate country-specific worksheets.
- E*xporting:* Data export for the multi-criteria analysis has the requirements that 1) any empty columns (with zero values) for specific technologies missing from the different countries must be eliminated, 2) the format

must preserve enough significant digits -in practice, this means formatting in scientific notation, and 3) the matrix of data must be transposed, since the multi-criteria stakeholder survey input requires that rows contain technologies and columns contain indicators. The resulting text block is cut-and-pasted into the text data file, and spreadsheet delimiter character (tab) is replaced with the standard data file delimiter (;).

3. Contents of the Database

Presentation of Results

The contents of the NEEDS database are presented below in three sections. The first, Table 1, presents the technologies present in the database. Table 2 presents the NEEDS hierarchy of sustainability criteria. Appendix 1 then presents the data contents of the database in the form of 16 pages of tables. Finally, Appendix 2 presents the contents of the database as a series of 36 graphs. There is one bar graph for each indicator, showing the results for each technology by a group of 4 columns, one for each country.

Table 1 – This table shows a very brief column of technical data describing each technology, in order from nuclear plants to fossil to renewables. The data includes fuel, plant size, efficiency, annual generation, construction time, plant life, capital cost and average cost per kWh. This table is intended to simply make this database report somewhat more self standing – a more complete reference to the NEEDS technologies is also available in the links section of this website that also supplies more descriptive text, including socially relevant factors and representative photographs and diagrams for each technology.

The basic LCA and cost data for each technology that has been supplied by other NEEDS collaborators includes data for the years 2000, 2025 and 2050. For the future years of 2025 and 2050 they contain three scenarios; "pessimistic," "realistic-optimistic" and "very optimistic." All indicators within the NEEDS database have been either taken from or based upon the "realistic-optimistic" scenario. These scenario descriptions do not have strict and consistent definitions between the various collaborators, and some technology developments are considerably more speculative than others – so the degrees of optimism contained in the data may vary (e.g. between renewables and more conventional fossil technologies). Readers must simply apply their own judgement of possible progress by 2050 to the contents of the NEEDS database.

Table 2 – This table shows the NEEDS hierarchy of sustainability criteria, separated into three major sections for the environment (green), the economy (yellow) and society (blue). The table columns include the hierarchy level, short name and description, the direction of the indicator scales (i.e. highest value = best or worst) and indicator units.

A complete description of the development of the NEEDS criteria hierarchy, and the full background and definition of each individual indicator is beyond the scope of this database report. For this description, the reader is referred to "Environmental, economic and social criteria and indicators for sustainability assessment of energy technologies" by Hirschberg, et al.

Appendix 1 – The contents of the NEEDS database are presented in Appendix 1 as a series of 16 tables. These are presented in the country order of France, Germany, Italy and Switzerland. There are four pages for each country. Pages 1 and 2 present the environmental and economic indicators for technologies 1 through 12 and 13 through 26, respectively. Pages 3 and 4 then present the social indicators for technologies 1 through 12 and 13 through 26, respectively. The criteria hierarchy is presented in the leftmost columns, including criterion number, name and units. The criteria are consistently color-coded using green for environment, yellow for economy and blue for social.

All levels of the criteria hierarchy are shown, but indicators are only quantified for the lowest level (each leaf of the branching structure). For this reason, some lines of the tables are grayed out and do not contain any numbers. The values that are common to all four countries reference a separate worksheet of the spreadsheet that has not been shown. These indicator values are in cells on four lines that contain numbers, but have been slightly grayed out.

Appendix 2 – The contents of the NEEDS database are presented in Appendix 2 in the form of vertical bar graphs. There are four bars (or columns) for each technology, reflecting the values for France, Germany, Italy and Switzerland (as labelled by the legend). As explained below, some technologies are not considered appropriate for all the different countries. In these cases, there may be three or even two columns for some technologies. The order of the columns is the same as for the tables presented in Appendix 1, i.e. nuclear followed by fossil and renewable technologies.

Country Differentiation

As has just been mentioned, there are reasons why the results shown in the tables and figures of Appendices 1 and 2 may vary between the four different countries. These reasons fall into the four different categories described below.

- *Resource availability:* Some technologies were eliminated from consideration as future technology options in 2050 based on assumed resource availability. The largest case of this assumption was for the fuel lignite. It was assumed that there would be no commercially available sources of lignite for Italy and Switzerland. Because lignite has a low energy content by weight, plants are normally located within a relatively short radius of a surface mine (often with transport by conveyor belt). Italy and Switzerland were assumed to have no lignite mines in 2050. Similarly the relatively low quality of the solar resource in Germany and Switzerland is the reason for eliminating the solar thermal technology (parabolic trough collectors), although solar photovoltaic technologies were retained. Offshore wind was also eliminated from landlocked Switzerland. It may be noted here that onshore wind and hydro were also eliminated from consideration in 2050, since these technologies were not covered in the LCA stream of NEEDS, which only addressed advanced electricity generation options.

- *Resource quality:* Hours per year of operation were varied by country for both wind and solar technologies, based on country-specific weather conditions.
- *Thermal efficiency:* Weather conditions (i.e. average annual ambient temperatures) were also assumed to affect the generation efficiency of technologies relying on thermal cycles where waste heat must be rejected to the environment. High summer temperatures can lead to derating (reducing) generation capacity, but this factor was handled by assuming that thermal efficiencies were approximately 3% lower in Italy, as compared to France, Germany and Switzerland. This rather crude assumption ignores climate variations with countries, but it was judged better to at least acknowledge the major differences between northern and southern Europe. Lower efficiency implies higher fuel consumption and higher results for a range of indicators related to the fuel supply chain. Non-thermal technologies were not affected by this assumption.
- *Environment related:* Environment, health and safety risk impacts all depend upon how a technology relates to its surrounding environment, including how emissions travel (wind direction), the presence of potentially affected species or population, etc. For most technologies, a rather generic site was defined for each country so that such indicators could be calculated. For some technologies (e.g. nuclear) a more specific site definition was required so that indicators like potential fatalities from an accident could be calculated.

Adjustments Made to Social Indicators

Many of the social indicators were quantified on an ordinal scale, based upon the opinions of social experts. The basic assumption of this survey was that the survey group would provide their expert opinions of what public attitudes or opinions would be in the year 2050.

Primarily due to the continuing development of the NEEDS criteria hierarchy during the project, there were some discrepancies between the technologies and indicators covered in the telephone survey, and the final data needed for the NEEDS database. These differences and the way that they were reconciled fall into the following categories.

- *Excess technologies:* The survey questions covered a number of technologies that were eliminated from the final NEEDS technology set, including hydro, onshore wind, geothermal, and wave power. These results were simply not incorporated in the final database.
- *Missing technologies:* The survey experts were asked their opinions of technologies separately that must in practice be combined, i.e. carbon capture and sequestration (CCS) must be combined with the relevant fossil

generation technology. The results for these separate questions were combined for generation options where both elements were present. In addition, the generation technology of biomass-fueled cogeneration present in the final NEEDS technology set was not present in the expert survey. For this case, the social indicators related to security of supply, social conflict, participative decision-making and acceptance were set equal to those for another renewable (solar), and the social indicators related to waste, technology innovation, health, perceived risk, proliferation, landscape degradation and noise were set equal to those for a fossil technology (pulverized coal).

- *Excess indicators:* The NEEDS indicator for perceived risk was based on three factors asked separately during the expert survey, i.e. perceived technological familiarity, personal control and catastrophic potential. These three factors were weighted equally in calculating the final indicator for perceived risk. Also, an original educational training indicator was cut from the final NEEDS database criteria set. The originally proposed indicator related to the likelihood of public mobilization against (or for) a technology was also eliminated, leaving the other originally proposed indicator estimating the necessity of public participation in the decision-making process for construction approval.

4. Summary and Conclusions

The NEEDS database is an essential step in combining the technology analysis contributions from many different NEEDS participants and passing them along to the NEEDS multi-criteria analysis effort. It also serves the role of summarizing these contributions in one place, and making them readily available to the NEEDS stakeholders and general public for information and discussion. The design and execution of the database in its spreadsheet format has fulfilled the basic design requirements, and is well suited to future revisions and dissemination.

Table 1 - NEEDS Technologies for 2050

		1	2	3	4	5	6	7	8	9	10	11	12
		Nuclear Plants		**Advanced Fossil**						**Integrated Gasification Combined Cycle**			
		EPR	**EFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Characteristics	**Units**	European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
Type of fuel		U235, 4.9%	Mixed Oxide	hard coal	hard coal	hard coal	lignite	lignite	lignite	hard coal	hard coal	lignite	lignite
Electric efficiency	%	0.37	0.4	0.54	0.49	0.47	0.54	0.49	0.47	0.545	0.485	0.525	0.465
Electric generation capacity	MW	1590	1450	600	500	500	950	800	800	450	400	450	400
Load factor (expected hours/yr)	hours/year	7916	7889	7600	7600	7600	7760	7760	7760	7500	7500	7500	7500
Annual generation (expected)	kWh/year	1.26E+10	1.14E+10	4.56E+09	3.80E+09	3.80E+09	7.37E+09	6.21E+09	6.21E+09	3.38E+09	3.00E+09	3.38E+09	3.00E+09
Construction time	years	4.8	5.5	3	3	3	3	3	3	3	3	3	3
Capital cost (net present value)	€/kWe	1498	1900	983	1560	1560	989	1560	1560	1209	1505	1209	1209
Total capital cost (net present value)	M€	2383	2756	590	780	780	939	1248	1248	544	602	544	483
Plant life	years	60	40	35	35	35	35	35	35	35	35	35	35
Average cost of electricity	€cents/kWhe	3.01	2.68	2.96	3.94	4.00	3.01	4.08	4.16	6.17	7.26	6.57	6.78

		13	14	15	16	17	18	19	20	21	22	23	24	25	26
					Fuel Cells				**Biomass CHP**		**Solar**				**Wind**
		GTCC	**GTCC CCS**	**IC CHP**	**MCFC NG**	**MCFC wood gas**	**MCFC NG**	**SOFC NG**	**CHP poplar**	**CHP straw**	**PV-Si plant**	**PV-Si building**	**PV-CdTe building**	**Solar thermal**	**Wind-offshore**
Characteristics	**Units**	Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	IC engine cogeneration	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
Type of fuel		natural gas	natural gas	natural gas	natural gas	wood gas	natural gas	natural gas	SRF poplar	waste straw	sun	sun	sun	sun	wind
Electric efficiency	%	0.65	0.61	0.44	0.5	0.5	0.55	0.58	0.3	0.3	0	0	0	0.185	0
Electric generation capacity	MW	1000	1000	0.2	0.25	0.25	2	0.3	9	9	46.6375	0.4197375	0.839475	400	24
Load factor (expected hours/yr)	hours/year	7200	7200	5000	5000	5000	5000	5000	8000	8000	984	984	984	4518	4000
Annual generation (expected)	kWh/year	7.20E+09	7.20E+09	1.00E+06	1.25E+06	1.25E+06	1.00E+07	1.50E+06	7.20E+07	7.20E+07	4.59E+07	4.13E+05	8.26E+05	1.81E+09	9.60E+07
Construction time	years	3	3	1	0.83	0.83	0.83	0.83	2	2	2	0.5	0.5	3	2
Capital cost (net present value)	€/kWe	440	615	879	1544	1544	1235	1030	2280	2280	848	927	927	3044	1130
Total capital cost (net present value)	M€	440	615	0	0	0	2	0	21	21	40	0	1	1217	27
Plant life	years	25	25	20	5	5	5	5	15	15	40	40	35	40	30
Average cost of electricity	€cents/kWhe	5.99	8.69	11.10	8.74	8.44	7.29	6.73	7.29	6.51	6.30	6.92	7.15	6.31	7.27

Table 2 - NEEDS Hierarchy of Sustainability Criteria

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
1	ENVIRONMENT	Environment related criteria Source: NEEDS Research Streams 1a & 2b, using Life Cycle Analysis (LCA)		
1.1	RESOURCES	Resource use (non-renewable)		
1.1.1	Energy	Energy resource use in whole life-cycle		
1.1.1.1	Fossil fuels	This criterion measures the total primary energy in the fossil resources used for the production of 1 kWh of electricity. It includes the total coal, natural gas and crude oil used for each complete technology chain. Note: Using coal fired technologies as an example; the total primary energy also includes the energy from oil used in transportation as well as from natural gas in the electricity mix used for mining and processing.	min	MJ/kWh
1.1.1.2	Uranium	This criterion quantifies the primary energy from uranium resources used to produce 1 kWh of electricity. It includes the total use of uranium for each complete electricity generation technology chain.	min	MJ/kWh
1.1.2	Minerals	Mineral resource use in whole life-cycle		
1.1.2.1	Metal ore	This criterion quantifies the use of selected scarce metals used to produce 1 kWh of electricity. It is based on the Life Cycle Impact Assessment method "CML 2001". The use of all single metals is expressed in antimony-equivalents, based on the scarcity of their ores relative to the reference ore (antimony).	min	kg(Sb-eq.)/kWh
1.2	CLIMATE	Potential impacts on the climate		
1.2.1.1	Carbon dioxide emissions (CO_2 emissions)	This criterion includes the total for all different greenhouse gases expressed in kg of CO_2 equivalent for each electricity generation technology. It addresses the potential negative impacts of global climate change caused by the greenhouse gases from the production of 1 kWh of electricity.	min	kg(CO_2-eq.)/kWh
1.3	ECOSYSTEMS	Potential impacts to ecosystems		
1.3.1	Normal operation (Normal op.)	Ecosystem impacts from normal operation		
1.3.1.1	Biodiversity	This criterion quantifies the loss of species (flora & fauna) due to the land used to produce 1 kWh of electricity. The "potentially damaged fraction" (PDF) of species is multiplied by land area and years for each complete electricity generation technology chain.	min	PDF*m^2*a/kWh

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
1.3.1.2	Ecotoxicity	This criterion quantifies the loss of species (flora & fauna) due to ecotoxic substances released to air, water and soil to produce 1 kWh of electricity. The "potentially damaged fraction" (PDF) of species is multiplied by land area and years for each complete electricity generation technology chain.	min	PDF*m^2*a/kWh
1.3.1.3	Air pollution	This criterion quantifies the loss of species (flora & fauna) due to acidification and eutrophication caused by pollution from production of 1 kWh of electricity. The "potentially damaged fraction" (PDF) of species is multiplied by land area and years for each complete electricity generation technology chain.	min	PDF*m^2*a/kWh
1.3.2	Severe accidents (Severe acc.)	Ecosystem impacts in the event of severe accidents		
1.3.2.1	Hydrocarbons	This criterion quantifies large accidental spills of hydrocarbons to the environment, which can potentially damage affected ecosystems. It considers severe accidents only, i.e. releases of at least 10000 tonnes.	min	t/GWeyr
1.3.2.2	Land contamination (Land contam.)	This criterion quantifies land contaminated due to accidents releasing radioactive isotopes. The land area contaminated is estimated using Probabilistic Safety Analysis (PSA). Note that this indicator is restricted to the nuclear electricity generation technology chain.	min	km^2/GWeyr
1.4	WASTE	Potential impacts due to waste		
1.4.1.1	Chemical waste	This criterion quantifies the total mass of special chemical wastes stored in underground repositories due to the production of 1 kWh of electricity. It does not reflect actual damage to humans or nature and does not reflect the confinement time required for each repository.	min	kg/kWh
1.4.1.2	Radioactive waste (Rad. waste)	This criterion quantifies the volume of low, medium and high level radioactive wastes stored in underground repositories due to the production of 1 kWh of electricity. It covers each complete electricity generation technology chain and does not reflect actual damage to humans or nature. It also does not reflect the confinement time required for the repository.	min	m^3/kWh
2	ECONOMY	Economy related criteria Source: NEEDS Research Stream 2b contributors for different technologies.		
2.1	CUSTOMERS	Economic effects on customers		
2.1.1.1	Generation cost (Gen. Cost)	This criterion gives the average generation cost per kilowatt-hour (kWh) for each technology, including the capital cost of the plant, (fuel), and operation and maintenance costs. It is the cost to the utility of generating electricity and not the end price that the customer must pay.	min	EUR/MWh
2.2	SOCIETY	Economic effects on society		

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
2.2.1.1	Direct jobs	This criterion gives the amount of employment directly related to building and operating the generating technology, including the direct labour involved in extracting or harvesting and transporting fuels (when applicable). Indirect labour (e.g fabricating plant components) is not included. The employment is measured in terms of man-years of labour and averaged over the generation, i.e. units are person-years/GWh.	max	Person-years/GWh
2.2.1.2	Fuel autonomy	Utility companies and the societies they serve may be vulnerable to interruptions in service if imported fuels are unavailable due to economic or political problems related to energy resource availability. This measure of vulnerability is based on expert judgment (of related factors), including whether a resource is domestic or imported, renewable or finite, and the relative size of different finite resources.	max	Ordinal
2.3	UTILITY	Economic effects on utility company		
2.3.1	Financial	Financial impacts on utility		
2.3.1.1	Financing risk	Utility companies can face a considerable financial risk if the total cost of a new electricity generating plant is very large compared to the overall size of the company. These risks can require forming necessary partnerships with other utilities or raising capital through financial markets.	min	Million EUR, NPV (NPV = Net Present Value)
2.3.1.2	Fuel sensitivity	The fraction of fuel cost to overall generation cost can range from zero (solar PV) to low (nuclear power) to high (gas turbines). This fraction therefore indicates how sensitive the generation costs would be to a change in fuel prices.	min	Factor
2.3.1.3	Construction time (Constr. Time)	Once a utility has started building a plant it is vulnerable to public opposition, resulting in delays and other problems, driving up the total cost. This indicator therefore gives the expected plant construction time in years. Time required for planning and regulatory approval is not included, as the bulk of spending occurs after the start of construction.	min	Years
2.3.2	Operation	Factors related to a utility company's operation of a technology.		
2.3.2.1	Marginal cost	Generating companies "dispatch" or order their plants into operation according to their variable cost, starting with the lowest cost baseload plants up to the highest cost plants at peak load periods. This variable (or dispatch) cost is the cost to run the plant, without the cost to build it. It is equal to the average fuel cost plus variable operation and maintenance costs per kilowatt-hour.	min	EUR-cents/kWh
2.3.2.2	Flexibility	In order to plan the operation of their generating plants at least a day in advance, utilities need forecasts of generation they cannot control (renewable resources like wind and solar), and the necessary start-up and shut-down times required for the plants they can control. This indicator combines these two measures of planning flexibility, based on expert judgment, including the logarithmic nature of planning time (the difference between 1 and 2 hours advance notice is more important in planning than the difference between 11 and 12 hours).	max	Ordinal

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
2.3.2.3	Availability	All technologies can have plant outages or partial outages (less than full generation), due to either equipment failures (forced outages) or due to maintenance (unforced or planned outages). This indicator tells the fraction of the time that the generating plant is available to generate power. Partial outages are accounted for by making an annual average equivalent availability factor, equal to the expected possible annual generation divided by maximum annual generation at full power.	max	Factor

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
3	SOCIAL	Socially related criteria Source: NEEDS Research Stream 2b survey of social experts for most indicators (indicated by ordinal scale for units). Quantitative risk measures based on PSI risk database.		
3.1	SECURITY	Social Security		
3.1.1	Political continuity (Pol. Continuity)	Political continuity		
3.1.1.1	Secure supply	This criterion refers to the market concentration of energy suppliers in each primary energy sector that could lead to economic or political disruption. It is based on expert judgement.	min	Ordinal scale
3.1.1.2	Waste repository (Waste repos.)	The criterion is based on the possibility that an infrastructure of storage facilities will not be available in time to take deliveries of waste materials from the fuel chain, including from the fuel supply, plant construction, operation and decommissioning of the plant.	min	Ordinal scale
3.1.1.3	Adaptability	The criterion refers to the technical characteristics of each electricity generation technology that may make it flexible in implementing technical progress and innovations.	max	Ordinal scale
3.2	POLITICAL LEGITIMACY (Political Legit.)	Political legitimacy		
3.2.1.1	Conflict	The indicator refers to conflicts that are based on historical evidence. It is related to the characteristics of energy systems that trigger conflicts.	min	Ordinal scale
3.2.1.2	Participation	This criterion is based on the fact that certain types of technologies require public, participative decision-making processes, especially for construction or operating permits or licenses.	min	Ordinal scale
3.3	RISK	Risk		
3.3.1	Normal risk	Normal operation risk Source: NEEDS Research Stream 2b for life cycle risk data		

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
3.3.1.1	Mortality	This criterion is based on the increased rate of mortality due to normal operation of the electricity generation technology and its associated energy chain. It is measured in the years of life lost (YOLL) by the entire population, compared to the expected lifetimes without the technology in question.	min	YOLL/kWh
3.3.1.2	Morbidity	This criterion is based on the increased rate of sickness or morbidity due to normal operation of the electricity generation technology and its associated energy chain. It is measured in the years of life affected by disabilities (disability adjusted life years, or DALY) suffered by the entire population, compared to their expected health without the technology in question.	min	DALY/kWh
3.3.2	Severe accidents (Sev. Accidents)	Risk from severe Accidents Source: NEEDS Research Stream 2b for severe accident data		
3.3.2.1	Accident mortality (Acc. Mortality)	This criterion is based on the number of fatalities expected for each kWh of electricity that occur in severe accidents with 5 or more deaths per accident for a particular electricity generation technology chain.	min	Fatalities/GWeyr
3.3.2.2	Maximum fatalities (Max. fatalities)	This criterion is based on the maximum number of fatalities that are reasonably credible for a single accident for a particular electricity generation technology chain.	min	Fatalities/accident
3.3.3	Perceived risk	Perceived risk		
3.3.3.1	Normal operation	This criterion is based on citizens' fear of negative health effects due to normal operation of the electricity generation technology.	min	Ordinal scale
3.3.3.2	Perceived accidents (Perceived acc.)	This criterion is based on citizens' perception of risk characteristics, including whether they can control the risk personally, whether the potential damage is small or catastrophic, and their familiarity with the risk.	min	Ordinal scale
3.3.4	Terrorism	Risk of terrorism		
3.3.4.1	Terror-Potential	This criterion indicates the potential for a successful terrorist attack on a specific technology, based on its vulnerability, the potential damage and public perception of risk.	min	Ordinal scale
3.3.4.2	Terror-Effects	This criterion concerns the potential likely consequences of a successful terrorist attack. The criterion implicitly addresses the aversion towards low-probability high-consequence accidents.	min	Expected number of fatalities
3.3.4.3	Proliferation	This criterion represents the potential for misuse of technologies or substances present in the nuclear electricity generation technology chain, based on both their presence and the risk of such misuse or diversion.	min	Ordinal scale

Hierarchy level	Criteria name (short name)	Description	Best value = min. or max.	Unit
3.4	RESIDENTIAL ENVIRONMENT (Residential env.)	Quality of the residential environment		
3.4.1.1	Landscape	This criterion is based on the overall functional and aesthetic impact on the landscape of the entire infrastructure related to each electricity generation technology chain, including mines, transmission lines or pipelines, structures, etc. Note: Excludes traffic.	min	Ordinal scale
3.4.1.2	Noise	This criterion is based on the amount of noise caused by the generation plant, as well as transport of materials to and from the plant (e.g. trucking of fuel and/or waste).	min	Ordinal scale

Appendix 1 – NEEDS Database Tables for All Countries

Table 1.1 NEEDS Database for France, Environmental & Economic Indicators for Technologies 1-12

France

Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	**Units**												
1	ENVIRONMENT													
1.1	Resources													
1.1.1	Energy													
1.1.1.1	Fossil Fuels	MJ/kWh	6.76E-02	1.47E-02	6.99E+00	7.99E+00	8.18E+00	7.59E+00	8.67E+00	8.86E+00	6.90E+00	7.87E+00	7.82E+00	8.97E+00
1.1.1.2	Uranium	MJ/kWh	1.29E+01	7.45E-03	9.35E-02	2.00E-01	2.09E-01	3.07E-02	1.47E-01	1.54E-01	9.34E-02	1.93E-01	3.72E-02	1.50E-01
1.1.2	Minerals													
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	5.22E-08	2.42E-08	1.32E-07	2.75E-07	2.62E-07	8.80E-08	2.48E-07	2.30E-07	1.19E-07	2.13E-07	7.47E-08	1.82E-07
1.2	Climate													
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	4.25E-03	9.14E-04	6.85E-01	1.58E-01	8.43E-02	7.38E-01	1.11E-01	2.58E-02	6.76E-01	1.47E-01	7.60E-01	1.08E-01
1.3	Ecosystems													
1.3.1	Normal Op.													
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.19E-04	5.62E-05	5.14E-03	6.30E-03	6.51E-03	7.09E-04	1.52E-03	1.50E-03	5.25E-03	6.39E-03	1.02E-03	1.86E-03
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	5.28E-04	2.83E-04	2.06E-03	2.87E-03	2.66E-03	7.67E-04	1.27E-03	1.10E-03	1.71E-03	2.07E-03	2.53E-03	2.98E-03
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.68E-04	1.92E-05	5.35E-03	9.29E-03	4.57E-03	3.44E-03	7.59E-03	1.65E-03	3.88E-03	4.55E-03	2.82E-03	3.60E-03
1.3.2	Severe Acc.													
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	3.15E-06	6.95E-05	0	0	0	0	0	0	0	0	0	0
1.4	Waste													
1.4.1	Chem waste	kg/kWh	6.90E-10	2.17E-10	1.36E-08	1.58E-08	7.27E-09	2.13E-08	2.43E-08	9.14E-09	4.96E-10	6.60E-10	2.28E-10	3.92E-10
1.4.2	Rad waste	m3/kWh	1.03E-08	3.22E-09	7.58E-11	1.62E-10	1.70E-10	2.49E-11	1.18E-10	1.25E-10	7.56E-11	1.56E-10	3.01E-11	1.21E-10
2	ECONOMY													
2.1	Customers													
2.1.1	Gen Cost	€/MWh	30.1	26.8	29.6	39.4	40.0	30.1	40.8	41.6	61.7	72.6	65.7	67.8
2.2	Society													
2.2.1	Jobs	Person-years/GWh	61	71	54	77	78	69	94	95	63	76	80	84
2.2.2	Fuel Autonomy	Ordinal	8	8	6	6	6	0	0	0	6	6	0	0
2.3	Utility													
2.3.1	Financial													
2.3.1.1	Financing Risk	€	2383	2756	590	780	780	939	1248	1248	544	602	544	483
2.3.1.2	Fuel Sensitivity	Factor	0.26	0.00	0.43	0.35	0.36	0.53	0.43	0.44	0.20	0.19	0.25	0.27
2.3.1.3	Constr. Time	Years	4.83	5.5	3	3	3	3	3	3	3	3	3	3
2.3.2	Operation													
2.3.2.1	Marginal Cost	€cents/kWh	1.2	0.4	1.5	1.7	1.8	1.7	1.9	2.0	4.4	5.0	4.8	5.0
2.3.2.2	Flexibility	Ordinal	6	6	8	8	8	8	8	8	7	7	7	7
2.3.2.3	Availability	Factor	0.90	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
3	SOCIAL													

Table 1.2 NEEDS Database for France, Environmental & Economic Indicators for Technologies 13-26

France

Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						Fuel Cells				Biomass CHP		Solar				Wind
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG	CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
1.1	Resources															
1.1.1	Energy															
1.1.1.1	Fossil Fuels	MJ/kWh	6.79E+00	7.44E+00	8.66E+00	7.99E+00	6.05E-01	7.33E+00	7.46E+00	2.64E-01	1.12E-01	1.43E-01	1.39E-01	5.86E-02	2.32E-01	5.46E-02
1.1.1.2	Uranium	MJ/kWh	1.02E-01	2.26E-01	1.35E-01	1.33E-01	3.21E-01	1.19E-01	1.32E-01	1.38E-02	7.05E-03	4.83E-02	4.84E-02	1.98E-02	2.00E-02	9.70E-03
1.1.2	Minerals															
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	8.25E-08	1.61E-07	1.40E-07	3.19E-07	4.34E-07	2.24E-07	1.40E-07	1.48E-07	8.01E-08	2.39E-06	2.40E-06	3.84E-07	1.44E-07	3.56E-06
1.2	Climate															
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	3.91E-01	1.26E-01	5.26E-01	4.79E-01	4.00E-02	4.39E-01	4.42E-01	5.31E-02	3.28E-02	8.21E-03	8.64E-03	2.95E-03	2.29E-02	2.84E-03
1.3	Ecosystems															
1.3.1	Normal Op.															
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.18E-03	2.95E-03	2.92E-03	2.99E-03	3.81E-01	2.69E-03	2.55E-03	8.01E-01	1.00E-04	3.85E-03	3.88E-04	2.29E-04	5.22E-03	1.57E-04
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	3.83E-04	6.34E-04	4.05E-04	2.30E-03	2.71E-03	1.64E-03	5.95E-04	6.11E-04	2.82E-04	1.95E-03	1.98E-03	8.41E-04	1.21E-03	8.78E-04
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.10E-03	1.29E-03	1.49E-03	1.26E-03	3.35E-03	1.14E-03	1.22E-03	8.76E-03	9.44E-03	2.29E-04	2.28E-04	8.62E-05	5.32E-04	8.67E-05
1.3.2	Severe Acc.															
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.4	Waste															
1.4.1	Chem waste	kg/kWh	4.49E-09	5.29E-09	6.13E-09	8.15E-09	3.18E-09	7.13E-09	8.89E-09	3.85E-10	2.22E-10	5.98E-09	3.33E-09	1.68E-09	5.72E-09	1.90E-09
1.4.2	Rad waste	m3/kWh	8.22E-11	1.82E-10	1.09E-10	1.07E-10	2.60E-10	9.59E-11	9.80E-11	1.10E-11	5.65E-12	3.71E-11	3.82E-11	1.52E-11	1.64E-11	7.32E-12
2	ECONOMY															
2.1	Customers															
2.1.1	Gen Cost	€/MWh	59.9	86.9	111.0	87.4	84.4	72.9	67.3	72.9	65.1	63.0	69.2	71.5	63.1	72.7
2.2	Society															
2.2.1	Jobs	Person-years/GWh	89	97	76	406	173	338	203	405	236	123	126	140	100	48
2.2.2	Fuel Autonomy	Ordinal	3	3	3	3	10	3	3	10	10	10	10	10	10	10
2.3	Utility															
2.3.1	Financial															
2.3.1.1	Financing Risk	€	440	615	0	0.39	0.39	2.47	0.31	21	21	40	0	1	1217	27
2.3.1.2	Fuel Sensitivity	Factor	0.54	0.39	0.36	0.41	0.38	0.44	0.48	0.52	0.43	0.00	0.00	0.00	0.00	0.00
2.3.1.3	Constr. Time	Years	3	3	1	0.83	0.83	0.83	0.83	2	2	2	0.5	0.5	3	2
2.3.2	Operation															
2.3.2.1	Marginal Cost	€cents/kWh	5.4	7.8	10.8	4.2	3.7	3.8	3.6	5.5	3.9	0.0	0.2	0.2	0.0	4.7
2.3.2.2	Flexibility	Ordinal	10	10	10	7	7	7	7	7	7	2	2	2	2	3
2.3.2.3	Availability	Factor	0.85	0.85	0.97	0.99	0.99	0.99	0.99	0.85	0.85	0.11	0.11	0.11	0.52	0.46
3	SOCIAL															

Table 1.3 NEEDS Database for France, Social Indicators for Technologies 1-12

France

Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
2	ECONOMY													
3	SOCIAL													
3.1	Security													
3.1.1	Pol. continuity													
3.1.1.1	Secure Supply	Ordinal scale	4	3.5	3.5	3	3	3.5	3	3	3	3	3	3
3.1.1.2	Waste repos.	Ordinal scale	2	2	2	3	3	2	3	3	2	3	2	3
3.1.2	Adaptability	Ordinal scale	3	3	2	2	2	2	2	2	4	3	4	3
3.2	Political legit.													
3.2.1	Conflict	Ordinal scale	3	3	3	3	3	3	3	3	2	2	2	2
3.2.2	Participation	Ordinal scale	4.5	4	4	4	4	4	4	4	4	4	4	4
3.3	Risk													
3.3.1	Normal risk													
3.3.1.1	Mortality	YOLL/kWh	1.51E-08	2.19E-09	1.76E-07	2.07E-07	1.47E-07	9.49E-08	1.46E-07	6.21E-08	1.26E-07	1.49E-07	1.18E-07	1.51E-07
3.3.1.2	Morbidity	DALY/kWh	8.67E-09	1.31E-09	1.34E-07	1.54E-07	1.13E-07	7.28E-08	1.07E-07	4.69E-08	9.60E-08	1.14E-07	8.90E-08	1.14E-07
3.3.2	Sev. Accidents													
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	5.11E-06	9.40E-05	1.21E-01	1.34E-01	1.40E-01	4.90E-02	5.51E-02	5.74E-02	1.19E-01	1.35E-01	5.04E-02	5.80E-02
3.3.2.2	Max. fatalities	Fatalities/accident	26790	1858	272	272	272	51	51	51	272	272	51	51
3.3.3	Perceived risk													
3.3.3.1	Normal op.	Ordinal scale	4	4	3	4	4	3	4	4	3	4	3	4
3.3.3.2	Perceived Acc.	Ordinal scale	3.67	3.50	2.50	3.67	3.67	2.50	3.67	3.67	3.00	3.67	3.00	3.67
3.3.4	Terrorism													
3.3.4.1	Potential	Ordinal scale	6.5	6.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
3.3.4.2	Effects	Expected number of fatalities	10	10	2	3	3	2	3	3	2	3	2	3
3.3.4.3	Proliferation		1	1	0	0	0	0	0	0	0	0	0	0
3.4	Quality of Residential Environment													
3.4.1	Landscape	Ordinal scale	3.5	3.5	4	4	4	4	4	4	4	4	4	4
3.4.2	Noise	Ordinal scale	2	2	2	3	3	2	3	3	3	3	3	3

Table 1.4 NEEDS Database for France, Social Indicators for Technologies 13-26

France

Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						Fuel Cells				Biomass CHP		Solar				Wind
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG	CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
2	ECONOMY															
3	SOCIAL															
3.1	Security															
3.1.1	Pol. continuity															
3.1.1.1	Secure Supply	Ordinal scale	3	3	3	3	3	3	3	2.5	2.5	2.5	2.5	2.5	3	3.5
3.1.1.2	Waste repos.	Ordinal scale	1	3	1	1	1	1	1	2	2	0	0	0	0	0
3.1.2	Adaptability	Ordinal scale	3	3	3	4	4	4	4	2	2	4	4	4	4	4
3.2	Political legit.															
3.2.1	Conflict	Ordinal scale	2	3	2	2	2	2	2	2	2	2	2	2	1	2
3.2.2	Participation	Ordinal scale	4	4	4	3.5	3.5	3.5	3.5	4	4	4	4	4	4	3.5
3.3	Risk															
3.3.1	Normal risk															
3.3.1.1	Mortality	YOLL/kWh	3.42E-08	4.09E-08	4.48E-08	4.18E-08	9.35E-08	3.73E-08	3.86E-08	1.80E-07	2.57E-07	9.92E-09	1.03E-08	5.44E-09	1.68E-08	4.78E-09
3.3.1.2	Morbidity	DALY/kWh	2.66E-08	3.18E-08	3.50E-08	3.29E-08	7.17E-08	2.92E-08	3.02E-08	1.40E-07	1.97E-07	9.82E-09	1.02E-08	4.92E-09	1.48E-08	5.11E-09
3.3.2	Sev. Accidents															
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	6.86E-02	7.40E-02	1.01E-01	8.92E-02	2.99E-02	8.11E-02	7.69E-02	1.68E-02	1.68E-02	1.00E-04	1.00E-04	1.00E-04	2.00E-04	2.77E-03
3.3.2.2	Max. fatalities	Fatalities/accident	109	109	109	109	27	109	109	10	10	5	5	5	5	10
3.3.3	Perceived risk															
3.3.3.1	Normal op.	Ordinal scale	3	4	3	2	2	2	2	3	3	1	1	1	1	1
3.3.3.2	Perceived Acc.	Ordinal scale	2.67	4.00	3.00	2.83	2.83	2.83	2.83	2.50	2.50	2.67	2.67	2.67	2.67	2.17
3.3.4	Terrorism															
3.3.4.1	Potential	Ordinal scale	6.9	6.9	5.9	5.9	2	5.9	5.9	1	1	2	2	3	1	2
3.3.4.2	Effects	Expected number of fatalities	5	6	5	5	3	5	5	1	1	2	2	3	1	2
3.3.4.3	Proliferation		0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.4	Quality of Residential Environment															
3.4.1	Landscape	Ordinal scale	3	3	2	2	2	2	2	4	4	3	3	3	3	2
3.4.2	Noise	Ordinal scale	2	3	2	2	2	2	2	2	2	1	1	1	1	1

Table 1.5 NEEDS Database for Germany, Environmental & Economic Indicators for Technologies 1-12

Germany

Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
1.1	Resources													
1.1.1	Energy													
1.1.1.1	Fossil Fuels	MJ/kWh	6.76E-02	1.47E-02	6.99E+00	7.99E+00	8.18E+00	7.65E+00	8.73E+00	8.92E+00	6.90E+00	7.87E+00	7.88E+00	9.04E+00
1.1.1.2	Uranium	MJ/kWh	1.29E+01	7.45E-03	9.35E-02	2.00E-01	2.09E-01	5.39E-02	1.73E-01	1.80E-01	9.34E-02	1.93E-01	6.11E-02	1.77E-01
1.1.2	Minerals													
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	5.22E-08	2.42E-08	1.32E-07	2.75E-07	2.62E-07	9.76E-08	2.58E-07	2.41E-07	1.19E-07	2.13E-07	8.46E-08	1.93E-07
1.2	Climate													
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	4.25E-03	9.14E-04	6.85E-01	1.58E-01	8.43E-02	7.41E-01	1.14E-01	2.92E-02	6.76E-01	1.47E-01	7.63E-01	1.11E-01
1.3	Ecosystems													
1.3.1	Normal Op.													
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.19E-04	5.62E-05	5.14E-03	6.30E-03	6.51E-03	1.27E-03	2.14E-03	2.14E-03	5.25E-03	6.39E-03	1.59E-03	2.50E-03
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	5.28E-04	2.83E-04	2.06E-03	2.87E-03	2.66E-03	8.08E-04	1.32E-03	1.15E-03	1.71E-03	2.07E-03	2.57E-03	3.03E-03
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.68E-04	1.92E-05	5.35E-03	9.29E-03	4.57E-03	3.49E-03	7.65E-03	1.70E-03	3.88E-03	4.55E-03	2.86E-03	3.66E-03
1.3.2	Severe Acc.													
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	1.58E-06	3.47E-05	0	0	0	0	0	0	0	0	0	0
1.4	Waste													
1.4.1	Chem waste	kg/kWh	6.90E-10	2.17E-10	1.36E-08	1.58E-08	7.27E-09	2.13E-08	2.43E-08	9.17E-09	4.96E-10	6.60E-10	2.56E-10	4.23E-10
1.4.2	Rad waste	m3/kWh	1.03E-08	3.22E-09	7.58E-11	1.62E-10	1.70E-10	4.37E-11	1.39E-10	1.46E-10	7.56E-11	1.56E-10	4.94E-11	1.43E-10
2	ECONOMY													
2.1	Customers													
2.1.1	Gen Cost	€/MWh	30.1	26.8	29.6	39.4	40.0	30.1	40.8	41.6	61.7	72.6	65.7	67.8
2.2	Society													
2.2.1	Jobs	Person-years/GWh	61	71	54	77	78	69	94	95	63	76	80	84
2.2.2	Fuel Autonomy	Ordinal	8	8	6	6	6	6	6	6	6	6	6	6
2.3	Utility													
2.3.1	Financial													
2.3.1.1	Financing Risk	€	2383	2756	590	780	780	939	1248	1248	544	602	544	483
2.3.1.2	Fuel Sensitivity	Factor	0.26	0.00	0.43	0.35	0.36	0.53	0.43	0.44	0.20	0.19	0.25	0.27
2.3.1.3	Constr. Time	Years	4.83	5.5	3	3	3	3	3	3	3	3	3	3
2.3.2	Operation													
2.3.2.1	Marginal Cost	€cents/kWh	1.2	0.4	1.5	1.7	1.8	1.7	1.9	2.0	4.4	5.0	4.8	5.0
2.3.2.2	Flexibility	Ordinal	6	6	8	8	8	8	8	8	7	7	7	7
2.3.2.3	Availability	Factor	0.9	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
3	SOCIAL													

Table 1.6 NEEDS Database for Germany, Environmental & Economic Indicators for Technologies 13-26

Germany

	Criterion	Units	13	14	15	16	17	18	19
Technology Number			13	14	15	16	17	18	19
Technology Class						**Fuel Cells**			
Technology Name (short)			**GTCC**	**GTCC CCS**	**IC CHP**	**MCFC NG**	**MCFC wood gas**	**MCFC NG**	**SOFC NG**
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular), natural gas
1	ENVIRONMENT								
1.1	Resources								
1.1.1	Energy								
1.1.1.1	Fossil Fuels	MJ/kWh	6.38E+00	7.01E+00	8.14E+00	7.52E+00	6.05E-01	6.89E+00	7.02E+00
1.1.1.2	Uranium	MJ/kWh	7.18E-03	1.25E-01	1.57E-02	2.27E-02	3.21E-01	1.79E-02	2.96E-02
1.1.2	Minerals								
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	6.92E-08	1.47E-07	1.23E-07	3.05E-07	4.34E-07	2.11E-07	1.27E-07
1.2	Climate								
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	3.73E-01	1.06E-01	5.03E-01	4.57E-01	4.00E-02	4.19E-01	4.22E-01
1.3	Ecosystems								
1.3.1	Normal Op.								
1.3.1.1	Biodiversity	PDF*m2*a/kWh	1.20E-03	1.91E-03	1.67E-03	1.84E-03	3.81E-01	1.64E-03	1.49E-03
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	3.09E-04	5.54E-04	4.00E-04	2.21E-03	2.71E-03	1.56E-03	5.14E-04
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.15E-03	1.35E-03	1.55E-03	1.32E-03	3.35E-03	1.19E-03	1.27E-03
1.3.2	Severe Acc.								
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0	0	0
1.4	Waste								
1.4.1	Chem waste	kg/kWh	4.18E-09	4.96E-09	5.74E-09	7.78E-09	3.18E-09	6.80E-09	8.55E-09
1.4.2	Rad waste	m3/kWh	5.63E-12	1.01E-10	1.21E-11	1.74E-11	2.60E-10	1.37E-11	1.48E-11
2	ECONOMY								
2.1	Customers								
2.1.1	Gen Cost	€/MWh	59.9	86.9	111.0	87.4	84.4	72.9	67.3
2.2	Society								
2.2.1	Jobs	Person-years/GWh	89	97	76	406	173	338	293
2.2.2	Fuel Autonomy	Ordinal	3	3	3	3	10	3	3
2.3	Utility								
2.3.1	Financial								
2.3.1.1	Financing Risk	€	440	615	0	0.39	0.39	2.47	0.31
2.3.1.2	Fuel Sensitivity	Factor	0.54	0.39	0.36	0.41	0.38	0.44	0.48
2.3.1.3	Constr. Time	Years	3	3	1	0.83	0.83	0.83	0.83
2.3.2	Operation								
2.3.2.1	Marginal Cost	€cents/kWh	5.4	7.8	10.8	4.2	3.7	3.8	3.6
2.3.2.2	Flexibility	Ordinal	10	10	10	7	7	7	7
2.3.2.3	Availability	Factor	0.85	0.85	0.97	0.99	0.99	0.99	0.99
3	SOCIAL								

	Criterion	Units	20	21	22	23	24	25 (No solar thermal in DE)	26
Technology Number			20	21	22	23	24	25	26
Technology Class			**Biomass CHP**		**Solar**				**Wind**
Technology Name (short)			**CHP poplar**	**CHP straw**	**PV-Si plant**	**PV-Si building**	**PV-CdTe building**	**Solar thermal**	**Wind-offshore**
Technology Name (long)			Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
1	ENVIRONMENT								
1.1	Resources								
1.1.1	Energy								
1.1.1.1	Fossil Fuels	MJ/kWh	2.64E-01	1.12E-01	1.74E-01	1.69E-01	7.13E-02		5.46E-02
1.1.1.2	Uranium	MJ/kWh	1.38E-02	7.05E-03	5.88E-02	5.89E-02	2.41E-02		9.70E-03
1.1.2	Minerals								
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	1.48E-07	8.01E-08	2.91E-06	2.92E-06	4.67E-07		3.56E-06
1.2	Climate								
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	5.31E-02	3.28E-02	9.98E-03	1.05E-02	3.59E-03		2.84E-03
1.3	Ecosystems								
1.3.1	Normal Op.								
1.3.1.1	Biodiversity	PDF*m2*a/kWh	8.01E-01	1.00E-04	4.69E-03	4.72E-04	2.79E-04		1.57E-04
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	6.11E-04	2.82E-04	2.38E-03	2.40E-03	1.02E-03		8.78E-04
1.3.1.3	Air pollution	PDF*m2*a/kWh	8.76E-03	9.44E-03	2.78E-04	2.77E-04	1.05E-04		8.67E-05
1.3.2	Severe Acc.								
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0		0
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0		0
1.4	Waste								
1.4.1	Chem waste	kg/kWh	3.85E-10	2.22E-10	7.28E-09	4.05E-09	2.04E-09		1.90E-09
1.4.2	Rad waste	m3/kWh	1.10E-11	5.65E-12	4.52E-11	4.65E-11	1.85E-11		7.32E-12
2	ECONOMY								
2.1	Customers								
2.1.1	Gen Cost	€/MWh	72.9	65.1	76.6	83.7	86.6		72.7
2.2	Society								
2.2.1	Jobs	Person-years/GWh	405	236	123	126	140		48
2.2.2	Fuel Autonomy	Ordinal	10	10	10	10	10		10
2.3	Utility								
2.3.1	Financial								
2.3.1.1	Financing Risk	€	21	21	40	0	1		27
2.3.1.2	Fuel Sensitivity	Factor	0.52	0.43	0.00	0.00	0.00		0.00
2.3.1.3	Constr. Time	Years	2	2	2	0.5	0.5		2
2.3.2	Operation								
2.3.2.1	Marginal Cost	€cents/kWh	5.5	3.9	0.0	0.2	0.2		4.7
2.3.2.2	Flexibility	Ordinal	7	7	2	2	2		3
2.3.2.3	Availability	Factor	0.85	0.85	0.09	0.09	0.09		0.46
3	SOCIAL								

Table 1.7 NEEDS Database for Germany, Social Indicators for Technologies 1-12

Germany

Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
2	ECONOMY													
3	SOCIAL													
3.1	Security													
3.1.1	Pol. continuity													
3.1.1.1	Secure Supply	Ordinal scale	4	4	4	4	4	4	4	4	4	4	4	4
3.1.1.2	Waste repos.	Ordinal scale	4.5	4.5	1.5	3.5	3.5	1.5	3.5	3.5	1.5	3.5	1.5	3.5
3.1.2	Adaptability	Ordinal scale	3	3	2	2	2	2	2	2	3	3	3	3
3.2	Political legit.													
3.2.1	Conflict	Ordinal scale	5	5	3	3	3	3	3	3	2.5	2.5	2.5	2.5
3.2.2	Participation	Ordinal scale	5	5	4	4	4	4	4	4	4	4	4	4
3.3	Risk													
3.3.1	Normal risk													
3.3.1.1	Mortality	YOLL/kWh	1.76E-08	2.56E-09	2.11E-07	2.42E-07	1.76E-07	1.15E-07	1.71E-07	7.73E-08	1.50E-07	1.78E-07	1.44E-07	1.83E-07
3.3.1.2	Morbidity	DALY/kWh	1.05E-08	1.61E-09	1.59E-07	1.79E-07	1.33E-07	8.72E-08	1.25E-07	5.80E-08	1.13E-07	1.34E-07	1.07E-07	1.36E-07
3.3.2	Sev. Accidents													
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	1.84E-06	3.38E-05	1.21E-01	1.34E-01	1.40E-01	4.90E-02	5.51E-02	5.74E-02	1.19E-01	1.35E-01	5.04E-02	5.80E-02
3.3.2.2	Max. fatalities	Fatalities/accident	9720	670	272	272	272	51	51	51	272	272	51	51
3.3.3	Perceived risk													
3.3.3.1	Normal op.	Ordinal scale	5	5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
3.3.3.2	Perceived Acc.	Ordinal scale	3.00	3.00	2.67	3.17	3.17	2.67	3.17	3.17	2.67	3.17	2.67	3.17
3.3.4	Terrorism													
3.3.4.1	Potential	Ordinal scale	6.5	6.5	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
3.3.4.2	Effects	Expected number of fatalities	10	10	2	3	3	2	3	3	2	3	2	3
3.3.4.3	Proliferation		1	1	0	0	0	0	0	0	0	0	0	0
3.4	Quality of Residential Environment													
3.4.1	Landscape	Ordinal scale	3	3	4	4	4	4	4	4	4	4	4	4
3.4.2	Noise	Ordinal scale	2	2	3	3	3	3	3	3	3	3	3	3

Table 1.8 NEEDS Database for Germany, Social Indicators for Technologies 13-26

Germany

															No solar thermal in DE	
Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						Fuel Cells				Biomass CHP		Solar				Wind
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG	CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular), natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
2	ECONOMY															
3	SOCIAL															
3.1	Security															
3.1.1	Pol. continuity															
3.1.1.1	Secure Supply	Ordinal scale	4	3.5	4	4	4	4	4	3	3	3	3	3		4
3.1.1.2	Waste repos.	Ordinal scale	1	3.5	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5		1
3.1.2	Adaptability	Ordinal scale	3	3	4	5	5	5	5	2	2	4	4	4		4
3.2	Political legit.															
3.2.1	Conflict	Ordinal scale	2	2.5	1	1	1	1	1	1	1	1	1	1		2
3.2.2	Participation	Ordinal scale	3.5	4	2	2	2	2	2	1.5	1.5	1.5	1.5	1.5		2
3.3	Risk															
3.3.1	Normal risk															
3.3.1.1	Mortality	YOLL/kWh	6.34E-08	7.35E-08	8.22E-08	7.59E-08	1.32E-07	6.81E-08	7.02E-08	2.67E-07	3.60E-07	1.59E-08	1.62E-08	8.52E-09		6.29E-09
3.3.1.2	Morbidity	DALY/kWh	4.71E-08	5.48E-08	6.14E-08	5.72E-08	9.90E-08	5.11E-08	5.26E-08	1.99E-07	2.68E-07	1.51E-08	1.54E-08	7.58E-09		6.46E-09
3.3.2	Sev. Accidents															
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	6.86E-02	7.40E-02	1.01E-01	8.92E-02	2.99E-02	8.11E-02	7.69E-02	1.68E-02	1.68E-02	1.00E-04	1.00E-04	1.00E-04		2.77E-03
3.3.2.2	Max. fatalities	Fatalities/accident	109	109	109	109	27	109	109	10	10	5	5	5		10
3.3.3	Perceived risk															
3.3.3.1	Normal op.	Ordinal scale	2	2.5	2	2	2	2	2	3.5	3.5	1	1	1		0.5
3.3.3.2	Perceived Acc.	Ordinal scale	3.00	3.17	1.67	2.00	2.00	2.00	2.00	2.67	2.67	2.00	2.00	2.00		2.33
3.3.4	Terrorism															
3.3.4.1	Potential	Ordinal scale	6.9	6.9	5.9	5.9	2	5.9	5.9	1	1	2	2	3		2
3.3.4.2	Effects	Expected number of fatalities	5	6	5	5	3	5	5	1	1	2	2	3		2
3.3.4.3	Proliferation		0	0	0	0	0	0	0	0	0	0	0	0		0
3.4	Quality of Residential Environment															
3.4.1	Landscape	Ordinal scale	3	3.75	1.25	1.25	1.25	1.25	1.25	4	4	1.75	1.75	1.75		2.75
3.4.2	Noise	Ordinal scale	2	3	1	1	1	1	1	3	3	1	1	1		1

Table 1.9 NEEDS Database for Italy, Environmental & Economic Indicators for Technologies 1-12

Italy								No lignite in Italy					No lignite in Italy	
Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
1.1	Resources													
1.1.1	Energy													
1.1.1.1	Fossil Fuels	MJ/kWh	6.99E-02	1.52E-02	7.22E+00	8.25E+00	8.45E+00				7.13E+00	8.13E+00		
1.1.1.2	Uranium	MJ/kWh	1.34E+01	7.70E-03	9.66E-02	2.07E-01	2.16E-01				9.64E-02	1.99E-01		
1.1.2	Minerals													
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	5.39E-08	2.50E-08	1.36E-07	2.84E-07	2.70E-07				1.23E-07	2.20E-07		
1.2	Climate													
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	4.39E-03	9.44E-04	7.08E-01	1.64E-01	8.70E-02				6.98E-01	1.52E-01		
1.3	Ecosystems													
1.3.1	Normal Op.													
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.26E-04	5.80E-05	5.31E-03	6.51E-03	6.72E-03				5.43E-03	6.60E-03		
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	5.45E-04	2.92E-04	2.13E-03	2.96E-03	2.75E-03				1.76E-03	2.14E-03		
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.73E-04	1.98E-05	5.52E-03	9.60E-03	4.72E-03				4.01E-03	4.71E-03		
1.3.2	Severe Acc.													
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0				0	0		
1.3.2.2	Land contam.	km2/GWe-yr	2.99E-06	6.60E-05	0	0	0				0	0		
1.4	Waste													
1.4.1	Chem waste	kg/kWh	7.13E-10	2.24E-10	1.41E-08	1.64E-08	7.51E-09				5.13E-10	6.82E-10		
1.4.2	Rad waste	m3/kWh	1.06E-08	3.32E-09	7.83E-11	1.67E-10	1.75E-10				7.81E-11	1.62E-10		
2	ECONOMY													
2.1	Customers													
2.1.1	Gen Cost	€/MWh	30.5	26.9	30.0	39.9	40.5				62.1	73.0		
2.2	Society													
2.2.1	Jobs	Person-years/GWh	61	71	54	77	78				63	76		
2.2.2	Fuel Autonomy	Ordinal	0	0	6	6	6				6	6		
2.3	Utility													
2.3.1	Financial													
2.3.1.1	Financing Risk	€	2383	2756	590	780	780				544	602		
2.3.1.2	Fuel Sensitivity	Factor	0.26	0.00	0.44	0.36	0.37				0.21	0.20		
2.3.1.3	Constr. Time	Years	4.83	5.5	3	3	3				3	3		
2.3.2	Operation													
2.3.2.1	Marginal Cost	€cents/kWh	1.2	0.5	1.6	1.7	1.8				4.4	5.1		
2.3.2.2	Flexibility	Ordinal	6	6	8	8	8				7	7		
2.3.2.3	Availability	Factor	0.90	0.90	0.85	0.85	0.85				0.85	0.85		
3	SOCIAL													

Table 1.10 NEEDS Database for Italy, Environmental & Economic Indicators for Technologies 13-26

Italy

	Criterion	Units	13	14	15	16	17	18	19
Technology Number			13	14	15	16	17	18	19
Technology Class						Fuel Cells			
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas
1	ENVIRONMENT								
1.1	Resources								
1.1.1	Energy								
1.1.1.1	Fossil Fuels	MJ/kWh	7.16E+00	7.85E+00	8.84E+00	8.16E+00	6.07E-01	7.48E+00	7.62E+00
1.1.1.2	Uranium	MJ/kWh	1.07E-01	2.35E-01	1.17E-01	1.35E-01	3.22E-01	1.21E-01	1.34E-01
1.1.2	Minerals								
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	8.85E-08	1.70E-07	1.44E-07	3.22E-07	4.36E-07	2.27E-07	1.43E-07
1.2	Climate								
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	4.11E-01	1.37E-01	5.34E-01	4.86E-01	4.30E-02	4.46E-01	4.49E-01
1.3	Ecosystems								
1.3.1	Normal Op.								
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.40E-03	3.23E-03	3.10E-03	3.15E-03	2.55E-01	2.85E-03	2.71E-03
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	4.03E-04	6.62E-04	5.03E-04	2.31E-03	2.72E-03	1.65E-03	6.02E-04
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.23E-03	1.44E-03	1.61E-03	1.37E-03	3.52E-03	1.24E-03	1.32E-03
1.3.2	Severe Acc.								
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0	0	0
1.4	Waste								
1.4.1	Chem waste	kg/kWh	4.74E-09	5.57E-09	6.25E-09	8.26E-09	3.19E-09	7.24E-09	9.00E-09
1.4.2	Rad waste	m3/kWh	8.62E-11	1.90E-10	1.11E-10	1.08E-10	2.60E-10	9.71E-11	9.92E-11
2	ECONOMY								
2.1	Customers								
2.1.1	Gen Cost	€/MWh	61.0	88.1	111.0	87.4	84.4	72.9	67.3
2.2	Society								
2.2.1	Jobs	Person-years/GWh	89	97	76	406	173	338	293
2.2.2	Fuel Autonomy	Ordinal	3	3	3	3	10	3	3
2.3	Utility								
2.3.1	Financial								
2.3.1.1	Financing Risk	€	440	615	0	0.39	0.39	2.47	0.31
2.3.1.2	Fuel Sensitivity	Factor	0.54	0.40	0.36	0.41	0.38	0.44	0.48
2.3.1.3	Constr. Time	Years	3	3	1	0.83	0.83	0.83	0.83
2.3.2	Operation								
2.3.2.1	Marginal Cost	€cents/kWh	5.5	7.9	10.8	4.2	3.7	3.8	3.6
2.3.2.2	Flexibility	Ordinal	10	10	10	7	7	7	7
2.3.2.3	Availability	Factor	0.85	0.85	0.97	0.99	0.99	0.99	0.99
3	SOCIAL								

	Criterion	Units	20	21	22	23	24	25	26
Technology Number			20	21	22	23	24	25	26
Technology Class			Biomass CHP		Solar				Wind
Technology Name (short)			CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
1	ENVIRONMENT								
1.1	Resources								
1.1.1	Energy								
1.1.1.1	Fossil Fuels	MJ/kWh	2.68E-01	1.12E-01	1.37E-01	1.33E-01	5.59E-02	2.22E-01	6.24E-02
1.1.1.2	Uranium	MJ/kWh	1.49E-02	7.05E-03	4.61E-02	4.61E-02	1.89E-02	1.91E-02	1.11E-02
1.1.2	Minerals								
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	1.51E-07	8.01E-08	2.28E-06	2.29E-06	3.66E-07	1.38E-07	4.07E-06
1.2	Climate								
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	5.93E-02	3.28E-02	7.83E-03	8.24E-03	2.81E-03	2.18E-02	3.25E-03
1.3	Ecosystems								
1.3.1	Normal Op.								
1.3.1.1	Biodiversity	PDF*m2*a/kWh	5.34E-01	1.00E-04	3.68E-03	3.70E-04	2.19E-04	4.98E-03	1.79E-04
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	6.42E-04	2.82E-04	1.86E-03	1.88E-03	8.02E-04	1.16E-03	1.00E-03
1.3.1.3	Air pollution	PDF*m2*a/kWh	9.12E-03	9.44E-03	2.18E-04	2.17E-04	8.22E-05	5.08E-04	9.91E-05
1.3.2	Severe Acc.								
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0	0	0
1.4	Waste								
1.4.1	Chem waste	kg/kWh	4.01E-10	2.22E-10	5.71E-09	3.17E-09	1.60E-09	5.46E-09	2.17E-09
1.4.2	Rad waste	m3/kWh	1.19E-11	5.65E-12	3.54E-11	3.64E-11	1.45E-11	1.57E-11	8.37E-12
2	ECONOMY								
2.1	Customers								
2.1.1	Gen Cost	€/MWh	73.8	65.7	60.1	66.0	68.3	60.2	76.4
2.2	Society								
2.2.1	Jobs	Person-years/GWh	405	236	123	126	140	100	48
2.2.2	Fuel Autonomy	Ordinal	10	10	10	10	10	10	10
2.3	Utility								
2.3.1	Financial								
2.3.1.1	Financing Risk	€	21	21	40	0	1	1217	27
2.3.1.2	Fuel Sensitivity	Factor	0.53	0.44	0.00	0.00	0.00	0.00	0.00
2.3.1.3	Constr. Time	Years	2	2	2	0.5	0.5	3	2
2.3.2	Operation								
2.3.2.1	Marginal Cost	€cents/kWh	5.6	4.0	0.0	0.2	0.2	0.0	4.7
2.3.2.2	Flexibility	Ordinal	7	7	2	2	2	2	3
2.3.2.3	Availability	Factor	0.85	0.85	0.12	0.12	0.12	0.54	0.40
3	SOCIAL								

Table 1.11 NEEDS Database for Italy, Social Indicators for Technologies 1-12

Italy								No lignite in Italy					No lignite in Italy	
Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			Nuclear Plants		Adv. Fossil									
Technology Name (short)			EPR	SFR	PC	PC-post CCS	PC-oxyfuel CCS	PL	PL-post CCS	PL-oxyfuel CCS	IGCC coal	IGCC coal CCS	IGCC lig	IGCC lig CCS
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
2	ECONOMY													
3	SOCIAL													
3.1	Security													
3.1.1	Pol. continuity													
3.1.1.1	Secure Supply	Ordinal scale	3	3.5	3.5	3.5	3.5				4	4		
3.1.1.2	Waste repos.	Ordinal scale	5	4.5	3	4	4				2	4		
3.1.2	Adaptability	Ordinal scale	3	4	2.5	2.5	2.5				3	3		
3.2	Political legit.													
3.2.1	Conflict	Ordinal scale	4.5	4.5	3.5	3.5	3.5				2.5	2.5		
3.2.2	Participation	Ordinal scale	5	5	4	4.5	4.5				4	4.5		
3.3	Risk													
3.3.1	Normal risk													
3.3.1.1	Mortality	YOLL/kWh	1.46E-08	2.12E-09	1.94E-07	2.12E-07	1.64E-07				1.35E-07	1.60E-07		
3.3.1.2	Morbidity	DALY/kWh	8.33E-09	1.28E-09	1.48E-07	1.61E-07	1.26E-07				1.03E-07	1.22E-07		
3.3.2	Sev. Accidents													
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	1.07E-05	2.02E-04	1.25E-01	1.38E-01	1.44E-01				1.23E-01	1.40E-01		
3.3.2.2	Max. fatalities	Fatalities/accident	51987	3621	272	272	272				272	272		
3.3.3	Perceived risk													
3.3.3.1	Normal op.	Ordinal scale	5	5	3.5	3.5	3.5				3.5	3.5		
3.3.3.2	Perceived Acc.	Ordinal scale	4.67	4.67	3.17	3.67	3.67				3.17	3.67		
3.3.4	Terrorism													
3.3.4.1	Potential	Ordinal scale	6.5	6.5	4.9	4.9	4.9				4.9	4.9		
3.3.4.2	Effects	Expected number of fatalities	10	10	2	3	3				2	3		
3.3.4.3	Proliferation		1	1	0	0	0				0	0		
3.4	Quality of Residential Environment													
3.4.1	Landscape	Ordinal scale	4	4	3.75	3.75	3.75				3.75	3.75		
3.4.2	Noise	Ordinal scale	2	2	3	3	3				3	3		

Table 1.12 NEEDS Database for Italy, Social Indicators for Technologies 13-26

Italy

Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						**Fuel Cells**				**Biomass CHP**		**Solar**				**Wind**
Technology Name (short)			**GTCC**	**GTCC CCS**	**IC CHP**	**MCFC NG**	**MCFC wood gas**	**MCFC NG**	**SOFC NG**	**CHP poplar**	**CHP straw**	**PV-Si plant**	**PV-Si building**	**PV-CdTe building**	**Solar thermal**	**Wind-offshore**
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentratin g solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
2	ECONOMY															
3	SOCIAL															
3.1	Security															
3.1.1	Pol. continuity															
3.1.1.1	Secure Supply	Ordinal scale	3	3	3	3	3	3	3	3	3	3	3	3	3	3.5
3.1.1.2	Waste repos.	Ordinal scale	1	4	1	1	1	1	1	3	3	2.5	2.5	2.5	2	2
3.1.2	Adaptability	Ordinal scale	3	3	3.5	4.5	4.5	4.5	4.5	2.5	2.5	4.5	4.5	4.5	4	4
3.2	Political legit.															
3.2.1	Conflict	Ordinal scale	3	3.5	1.5	1	1	1	1	1	1	1	1	1	1	1.5
3.2.2	Participation	Ordinal scale	3.5	4.5	2.5	1.5	1.5	1.5	1.5	3	3	3	3	3	3.5	4
3.3	Risk															
3.3.1	Normal risk															
3.3.1.1	Mortality	YOLL/kWh	3.80E-08	4.48E-08	4.79E-08	4.45E-08	9.33E-08	3.98E-08	4.11E-08	1.84E-07	2.41E-07	8.77E-09	9.03E-09	4.80E-09	1.53E-08	5.08E-09
3.3.1.2	Morbidity	DALY/kWh	2.95E-08	3.48E-08	3.74E-08	3.51E-08	7.21E-08	3.12E-08	3.22E-08	1.43E-07	1.85E-07	9.03E-09	9.27E-09	4.50E-09	1.42E-08	5.72E-09
3.3.2	Sev. Accidents															
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	7.09E-02	7.64E-02	1.01E-01	8.92E-02	2.99E-02	8.11E-02	7.69E-02	1.68E-02	1.68E-02	1.00E-04	1.00E-04	1.00E-04	2.07E-04	2.77E-03
3.3.2.2	Max. fatalities	Fatalities/accident	109	109	109	109	27	109	109	10	10	5	5	5	5	10
3.3.3	Perceived risk															
3.3.3.1	Normal op.	Ordinal scale	3	4	1	1	1	1	1	3.5	3.5	1	1	1	1	1
3.3.3.2	Perceived Acc.	Ordinal scale	2.67	3.67	3.00	3.00	3.00	3.00	3.00	3.17	3.17	2.17	2.17	2.17	2.00	2.67
3.3.4	Terrorism															
3.3.4.1	Potential	Ordinal scale	6.9	6.9	5.9	5.9	2	5.9	5.9	1	1	2	2	3	1	2
3.3.4.2	Effects	Expected number of fatalities	5	6	5	5	3	5	5	1	1	2	2	3	1	2
3.3.4.3	Proliferation		0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.4	Quality of Residential Environment															
3.4.1	Landscape	Ordinal scale	2.75	3.25	1.75	1.25	1.25	1.25	1.25	3.75	3.75	3	3	3	3	2
3.4.2	Noise	Ordinal scale	2	2	3	2	2	2	2	3	3	1	1	1	1.5	1

Table 1.13 NEEDS Database for Switzerland, Environmental & Economic Indicators for Technologies 1-12

Switzerland

No lignite in Switzerland (technologies 6–8) · No lignite in Switzerland (technologies 11–12)

Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			Nuclear Plants		Adv. Fossil									
Technology Name (short)			EPR	SFR	PC	PC-post CCS	PC-oxyfuel CCS	PL	PL-post CCS	PL-oxyfuel CCS	IGCC coal	IGCC coal CCS	IGCC lig	IGCC lig CCS
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
1.1	Resources													
1.1.1	Energy													
1.1.1.1	Fossil Fuels	MJ/kWh	6.76E-02	1.47E-02	6.99E+00	7.99E+00	8.18E+00				6.90E+00	7.87E+00		
1.1.1.2	Uranium	MJ/kWh	1.29E+01	7.45E-03	9.35E-02	2.00E-01	2.09E-01				9.34E-02	1.93E-01		
1.1.2	Minerals													
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	5.22E-08	2.42E-08	1.32E-07	2.75E-07	2.62E-07				1.19E-07	2.13E-07		
1.2	Climate													
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	4.25E-03	9.14E-04	6.85E-01	1.58E-01	8.43E-02				6.76E-01	1.47E-01		
1.3	Ecosystems													
1.3.1	Normal Op.													
1.3.1.1	Biodiversity	PDF*m2*a/kWh	2.19E-04	5.62E-05	5.14E-03	6.30E-03	6.51E-03				5.25E-03	6.39E-03		
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	5.28E-04	2.83E-04	2.06E-03	2.87E-03	2.66E-03				1.71E-03	2.07E-03		
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.68E-04	1.92E-05	5.35E-03	9.29E-03	4.57E-03				3.88E-03	4.55E-03		
1.3.2	Severe Acc.													
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0				0	0		
1.3.2.2	Land contam.	km2/GWe-yr	3.09E-06	6.81E-05	0	0	0				0	0		
1.4	Waste													
1.4.1	Chem waste	kg/kWh	6.90E-10	2.17E-10	1.36E-08	1.58E-08	7.27E-09				4.96E-10	6.60E-10		
1.4.2	Rad waste	m3/kWh	1.03E-08	3.22E-09	7.58E-11	1.62E-10	1.70E-10				7.56E-11	1.56E-10		
2	ECONOMY													
2.1	Customers													
2.1.1	Gen Cost	€/MWh	30.1	26.8	29.6	39.4	40.0				61.7	72.6		
2.2	Society													
2.2.1	Jobs	Person-years/GWh	61	71	54	77	78				63	76		
2.2.2	Fuel Autonomy	Ordinal	0	0	0	0	0				0	0		
2.3	Utility													
2.3.1	Financial													
2.3.1.1	Financing Risk	€	2383	2756	590	780	780				544	602		
2.3.1.2	Fuel Sensitivity	Factor	0.26	0.00	0.43	0.35	0.36				0.20	0.19		
2.3.1.3	Constr. Time	Years	4.83	5.5	3	3	3				3	3		
2.3.2	Operation													
2.3.2.1	Marginal Cost	€cents/kWh	1.2	0.4	1.5	1.7	1.8				4.4	5.0		
2.3.2.2	Flexibility	Ordinal	6	6	8	8	8				7	7		
2.3.2.3	Availability	Factor	0.9	0.90	0.85	0.85	0.85				0.85	0.85		
3	SOCIAL													

Table 1.14 NEEDS Database for Switzerland, Environmental & Economic Indicators for Technologies 13-26

Switzerland

															No solar thermal in CH	No offshore wind in CH
Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						**Fuel Cells**				**Biomass CHP**		**Solar**				**Wind**
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG	CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
1.1	Resources															
1.1.1	Energy															
1.1.1.1	Fossil Fuels	MJ/kWh	6.65E+00	7.30E+00	8.48E+00	7.83E+00	6.05E-01	7.19E+00	7.31E+00	2.64E-01	1.12E-01	1.53E-01	1.48E-01	6.25E-02		
1.1.1.2	Uranium	MJ/kWh	5.40E-02	1.75E-01	7.51E-02	7.74E-02	3.21E-01	6.82E-02	8.05E-02	1.38E-02	7.05E-03	5.16E-02	5.17E-02	2.12E-02		
1.1.2	Minerals															
1.1.2.1	Metal Ores	kg(Sb-eq.)/kWh	7.72E-08	1.55E-07	1.33E-07	3.13E-07	4.34E-07	2.19E-07	1.35E-07	1.48E-07	8.01E-08	2.55E-06	2.56E-06	4.10E-07		
1.2	Climate															
1.2.1	CO2 equiv	kg(CO2-eq.)/kWh	3.85E-01	1.19E-01	5.18E-01	4.72E-01	4.00E-02	4.32E-01	4.35E-01	5.31E-02	3.28E-02	8.76E-03	9.22E-03	3.15E-03		
1.3	Ecosystems															
1.3.1	Normal Op.															
1.3.1.1	Biodiversity	PDF*m2*a/kWh	1.75E-03	2.50E-03	2.38E-03	2.49E-03	3.81E-01	2.24E-03	2.09E-03	8.01E-01	1.00E-04	4.11E-03	4.14E-04	2.45E-04		
1.3.1.2	Ecotoxicity	PDF*m2*a/kWh	3.48E-04	5.96E-04	4.50E-04	2.26E-03	2.71E-03	1.60E-03	5.57E-04	6.11E-04	2.82E-04	2.08E-03	2.11E-03	8.97E-04		
1.3.1.3	Air pollution	PDF*m2*a/kWh	1.17E-03	1.37E-03	1.58E-03	1.35E-03	3.35E-03	1.22E-03	1.30E-03	8.76E-03	9.44E-03	2.44E-04	2.43E-04	9.20E-05		
1.3.2	Severe Acc.															
1.3.2.1	Hydrocarbons	t/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0		
1.3.2.2	Land contam.	km2/GWe-yr	0	0	0	0	0	0	0	0	0	0	0	0		
1.4	Waste															
1.4.1	Chem waste	kg/kWh	4.38E-09	5.17E-09	5.99E-09	8.02E-09	3.18E-09	7.02E-09	8.77E-09	3.85E-10	2.22E-10	6.39E-09	3.55E-09	1.79E-09		
1.4.2	Rad waste	m3/kWh	4.36E-11	1.41E-10	6.03E-11	6.17E-11	2.60E-10	5.45E-11	5.61E-11	1.10E-11	5.65E-12	3.96E-11	4.08E-11	1.62E-11		
2	ECONOMY															
2.1	Customers															
2.1.1	Gen Cost	€/MWh	59.9	86.9	111.0	87.4	84.4	72.9	67.3	72.9	65.1	67.2	73.7	76.2		
2.2	Society															
2.2.1	Jobs	Person-years/GWh	89	97	76	406	173	338	293	405	236	123	126	140		
2.2.2	Fuel Autonomy	Ordinal	0	0	0	0	10	0	0	10	10	10	10	10		
2.3	Utility															
2.3.1	Financial															
2.3.1.1	Financing Risk	€	440	615	0	0.39	0.39	2.47	0.31	21	21	40	0	1		
2.3.1.2	Fuel Sensitivity	Factor	0.54	0.39	0.36	0.41	0.38	0.44	0.48	0.52	0.43	0.00	0.00	0.00		
2.3.1.3	Constr. Time	Years	1	3	1	0.83	0.83	0.83	0.83	2	2	2	0.5	0.5		
2.3.2	Operation															
2.3.2.1	Marginal Cost	€cents/kWh	5.4	7.8	10.8	4.2	3.7	3.8	3.6	5.5	3.9	0.0	0.2	0.2		
2.3.2.2	Flexibility	Ordinal	10	10	10	7	7	7	7	7	7	2	2	2		
2.3.2.3	Availability	Factor	0.85	0.85	0.97	0.99	0.99	0.99	0.99	0.85	0.85	0.11	0.11	0.11		
3	SOCIAL															

Table 1.15 NEEDS Database for Switzerland, Social Indicators for Technologies 1-12

Switzerland

								No lignite in Switzerland					No lignite in Switzerland	
Technology Number			1	2	3	4	5	6	7	8	9	10	11	12
Technology Class			**Nuclear Plants**		**Adv. Fossil**									
Technology Name (short)			**EPR**	**SFR**	**PC**	**PC-post CCS**	**PC-oxyfuel CCS**	**PL**	**PL-post CCS**	**PL-oxyfuel CCS**	**IGCC coal**	**IGCC coal CCS**	**IGCC lig**	**IGCC lig CCS**
Technology Name (long)			European Pressurized Reactor	Sodium Fast Reactor (Gen IV Fast Breeder Reactor	Pulverized Coal (PC) steam plant	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Coal (PC) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Pulverized Lignite (PL) steam plant	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), post combustion	Pulverized Lignite (PL) plant with Carbon Capture & Storage (CCS), oxyfuel combustion	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)	Integrated Gasification Combined Cycle (IGCC)	Integrated Gasification Combined Cycle (IGCC) with Carbon Capture & Storage (CCS)
	Criterion	Units												
1	ENVIRONMENT													
2	ECONOMY													
3	SOCIAL													
3.1	Security													
3.1.1	Pol. continuity													
3.1.1.1	Secure Supply	Ordinal scale	2.5	2	2.5	2	2				2.5	2		
3.1.1.2	Waste repos.	Ordinal scale	4	4	3	3.5	3.5				3	3.5		
3.1.2	Adaptability	Ordinal scale	3	3	3	3	3				3	3		
3.2	Political legit.													
3.2.1	Conflict	Ordinal scale	5	5	2.5	2	2				2.5	2		
3.2.2	Participation	Ordinal scale	5	5	4	4	4				4	4		
3.3	Risk													
3.3.1	Normal risk													
3.3.1.1	Mortality	YOLL/kWh	1.94E-08	2.73E-09	2.74E-07	2.92E-07	2.28E-07				1.96E-07	2.32E-07		
3.3.1.2	Morbidity	DALY/kWh	1.16E-08	1.71E-09	2.02E-07	2.13E-07	1.68E-07				1.44E-07	1.70E-07		
3.3.2	Sev. Accidents													
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	8.56E-06	1.59E-04	1.21E-01	1.34E-01	1.40E-01				1.19E-01	1.35E-01		
3.3.2.2	Max. fatalities	Fatalities/accident	44090	3060	272	272	272				272	272		
3.3.3	Perceived risk													
3.3.3.1	Normal op.	Ordinal scale	4	4	3	3	3				3	3		
3.3.3.2	Perceived Acc.	Ordinal scale	4.67	4.67	3.67	3.33	3.33				3.67	3.33		
3.3.4	Terrorism													
3.3.4.1	Potential	Ordinal scale	6.5	6.5	4.9	4.9	4.9				4.9	4.9		
3.3.4.2	Effects	Expected number	10	10	2	3	3				2	3		
3.3.4.3	Proliferation		1	1	0	0	0				0	0		
3.4	Quality of Residential Environment													
3.4.1	Landscape	Ordinal scale	3.25	3.25	2.75	2.5	2.5				2.75	2.5		
3.4.2	Noise	Ordinal scale	2	2	4	3.5	3.5				4	3.5		

Table 1.16 NEEDS Database for Switzerland, Social Indicators for Technologies 13-26

Switzerland

															No solar thermal in CH	No offshore wind in CH
Technology Number			13	14	15	16	17	18	19	20	21	22	23	24	25	26
Technology Class						**Fuel Cells**				**Biomass CHP**		**Solar**				**Wind**
Technology Name (short)			GTCC	GTCC CCS	IC CHP	MCFC NG	MCFC wood gas	MCFC NG	SOFC NG	CHP poplar	CHP straw	PV-Si plant	PV-Si building	PV-CdTe building	Solar thermal	Wind-offshore
Technology Name (long)			Combined Cycle	Combined Cycle with Carbon Capture & Storage (CCS), post combustion	Combined Cycle Heat and Power	Molten Carbonate Fuel Cells, natural gas	Molten Carbonate Fuel Cells, wood gas	Molten Carbonate Fuel Cells, natural gas	Solid Oxide Fuel Cells (tubular, natural gas	Steam turbine cogeneration, short rotation forestry poplar	Steam turbine cogeneration, agricultural waste wheat straw	PV, Mono-crystalline Si, Plant Size	PV, Mono-crystalline Si, Building Integrated	CdTe, Building Integrated	Concentrating solar thermal power plant	Wind
	Criterion	Units														
1	ENVIRONMENT															
2	ECONOMY															
3	SOCIAL															
3.1	Security															
3.1.1	Pol. continuity															
3.1.1.1	Secure Supply	Ordinal scale	3	3	4	3	3	3	3	3	3	3	3	3		
3.1.1.2	Waste repos.	Ordinal scale	2	3.5	1	1	1	1	1	3	3	1	1	1		
3.1.2	Adaptability	Ordinal scale	3	2.5	3	5	5	5	5	3	3	4	4	4		
3.2	Political legit.															
3.2.1	Conflict	Ordinal scale	3	3	1.5	1	1	1	1	2	2	2	2	2		
3.2.2	Participation	Ordinal scale	3.5	4	1	1	1	1	1	2	2	2	2	2		
3.3	Risk															
3.3.1	Normal risk															
3.3.1.1	Mortality	YOLL/kWh	7.44E-08	8.65E-08	9.77E-08	8.86E-08	1.62E-07	7.97E-08	8.29E-08	3.45E-07	4.71E-07	1.62E-08	1.65E-08	8.37E-09		
3.3.1.2	Morbidity	DALY/kWh	5.42E-08	6.32E-08	7.14E-08	6.52E-08	1.19E-07	5.85E-08	6.07E-08	2.52E-07	3.43E-07	1.45E-08	1.48E-08	7.12E-09		
3.3.2	Sev. Accidents															
3.3.2.1	Exp. mortality	Fatalities/GWe-yr	6.86E-02	7.40E-02	1.01E-01	8.92E-02	2.99E-02	8.11E-02	7.69E-02	1.68E-02	1.68E-02	1.00E-04	1.00E-04	1.00E-04		
3.3.2.2	Max. fatalities	Fatalities/accident	109	109	109	109	27	109	109	10	10	5	5	5		
3.3.3	Perceived risk															
3.3.3.1	Normal op.	Ordinal scale	2	3	1	1	1	1	1	3	3	1	1	1		
3.3.3.2	Perceived Acc.	Ordinal scale	2.67	3.33	1.83	1.83	1.83	1.83	1.83	3.67	3.67	2.17	2.17	2.17		
3.3.4	Terrorism															
3.3.4.1	Potential	Ordinal scale	6.9	6.9	5.9	5.9	2	5.9	5.9	1	1	2	2	3		
3.3.4.2	Effects	Expected number	5	6	5	5	3	5	5	1	1	2	2	3		
3.3.4.3	Proliferation		0	0	0	0	0	0	0	0	0	0	0	0		
3.4	Quality of Residential Environment															
3.4.1	Landscape	Ordinal scale	2.5	2.5	1	1	1	1	1	2.75	2.75	2	2	2		
3.4.2	Noise	Ordinal scale	2	2.5	1	1	1	1	1	4	4	1	1	1		

Appendix 2 – NEEDS Database Figures for all Indicators

Figure 2.1 – Total Consumption of Fossil Resources

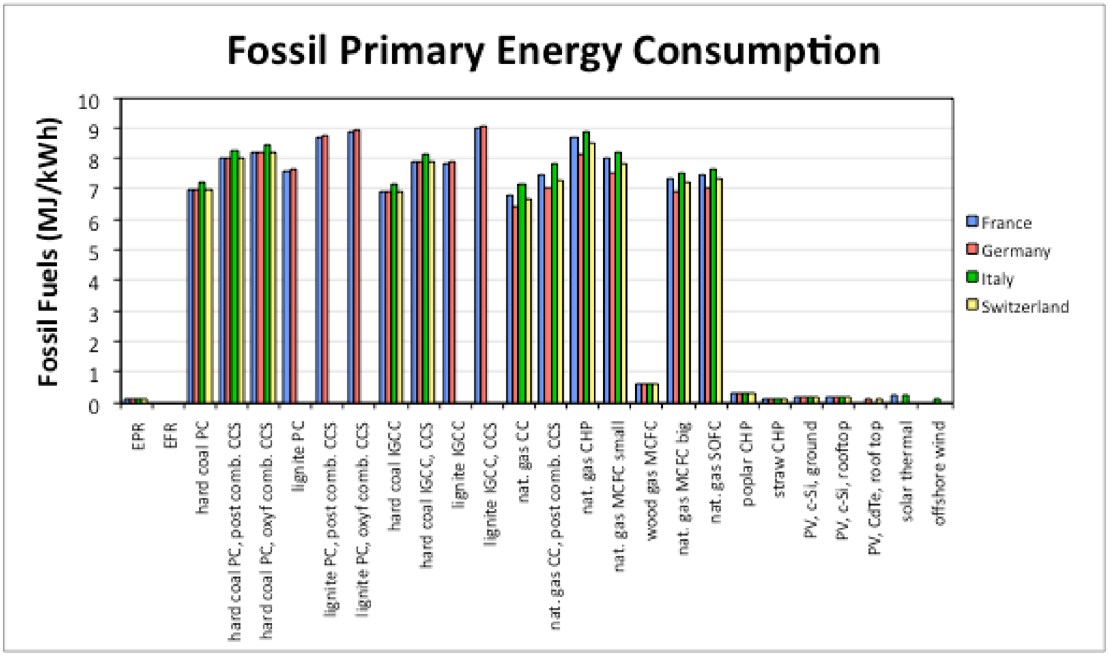


Figure 2.2 – Total Consumption of Uranium

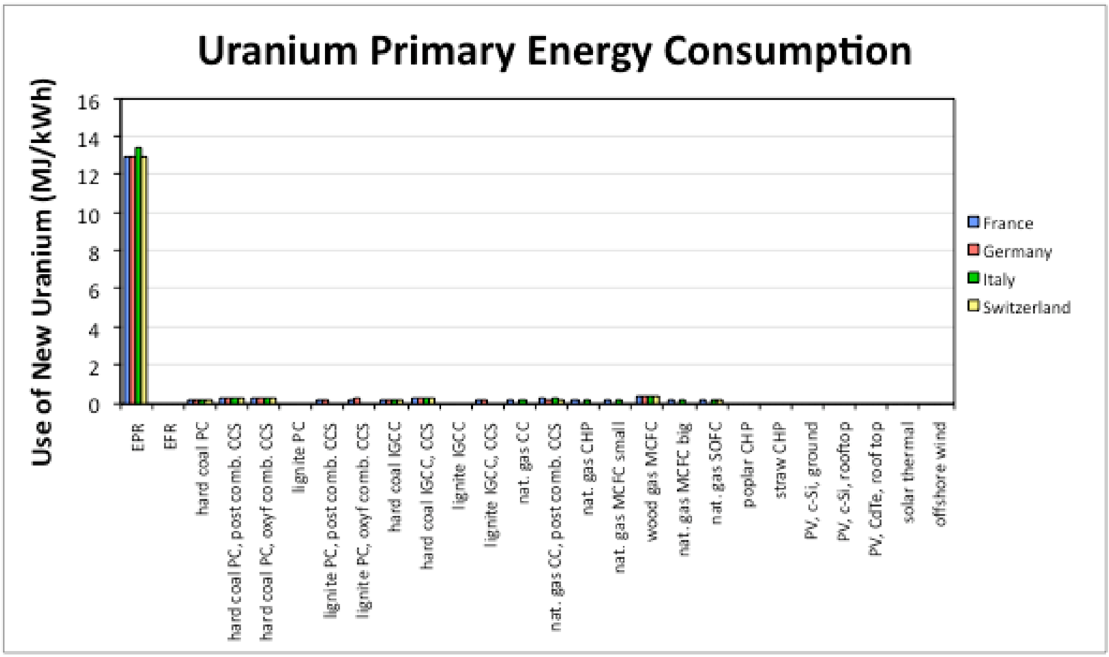


Figure 2.3 – Weighted Total Consumption of Metallic Ores

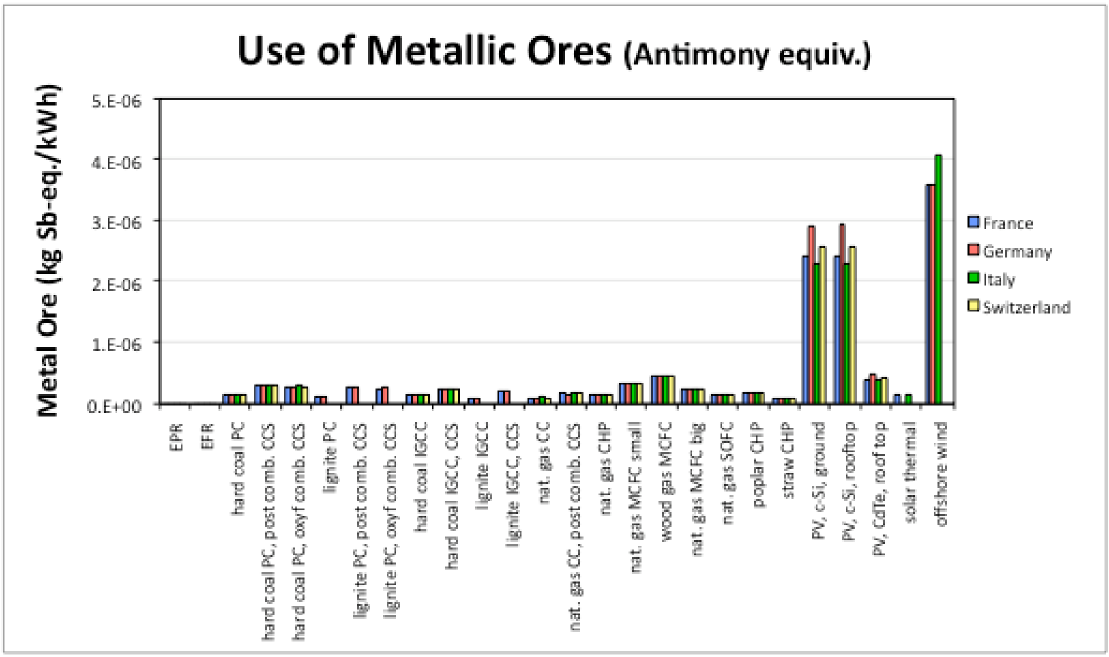


Figure 2.4 – Global Warming Potential

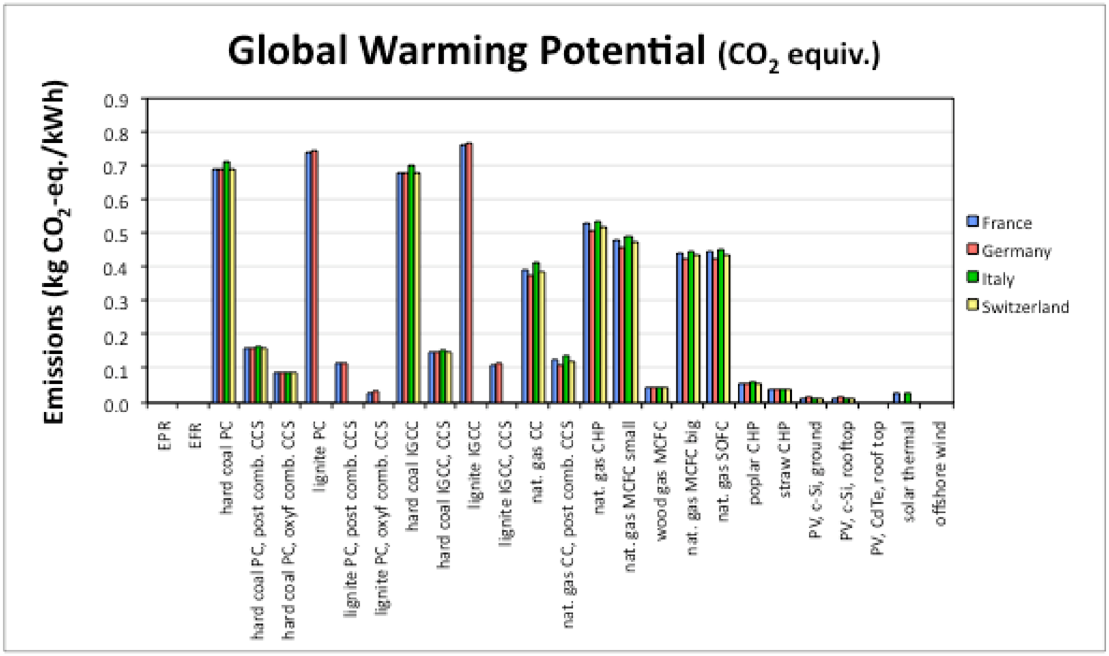


Figure 2.5 – Impacts of Land Use on Ecosystems

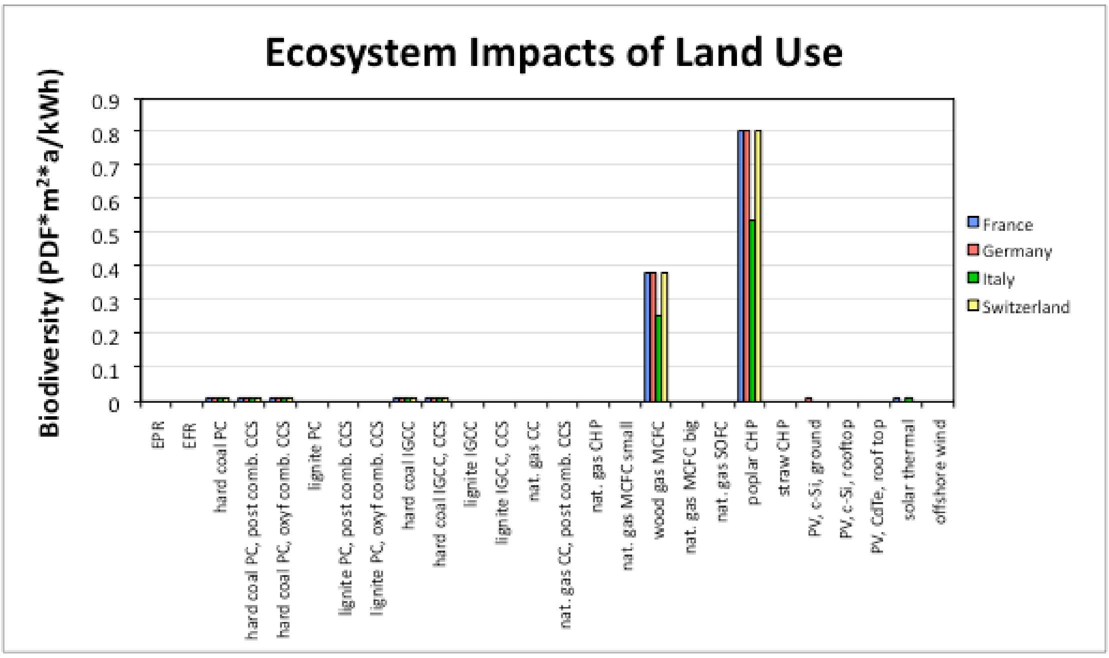


Figure 2.6 – Impacts of Toxic Substances on Ecosystems

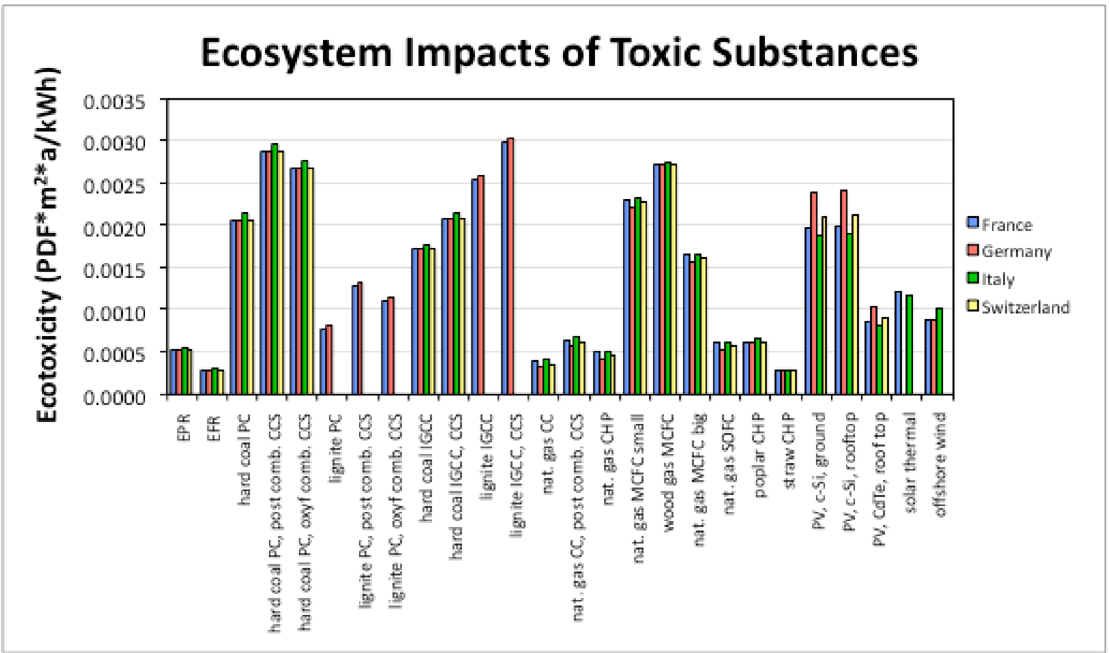


Figure 2.7 – Impacts of Air Pollution on Ecosystems

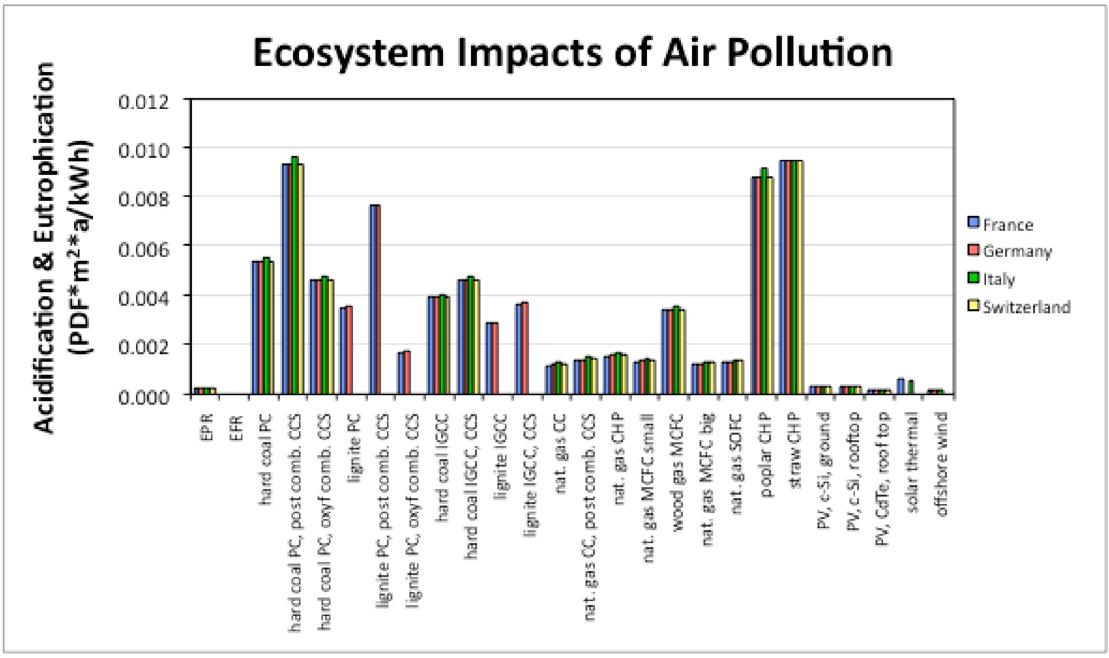
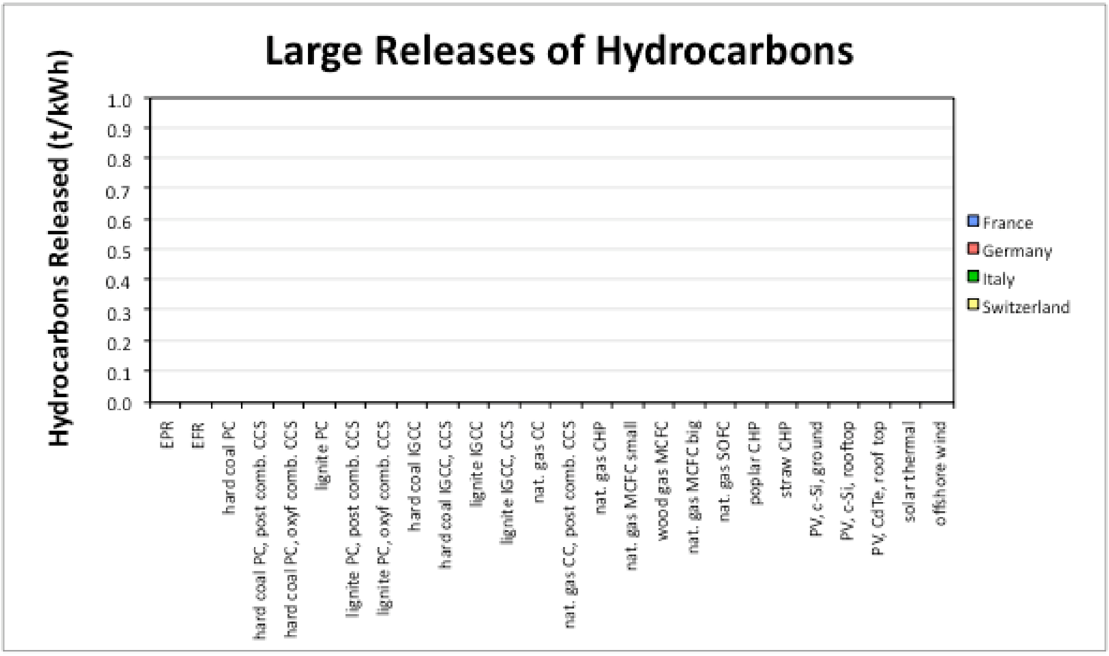


Figure 2.8 – Large Releases of Hydrocarbons



Note: Because no oil burning generation technologies were included, there is no potential for large oil spills in any of the energy chains.

Figure 2.9 – Nuclear Land Contamination

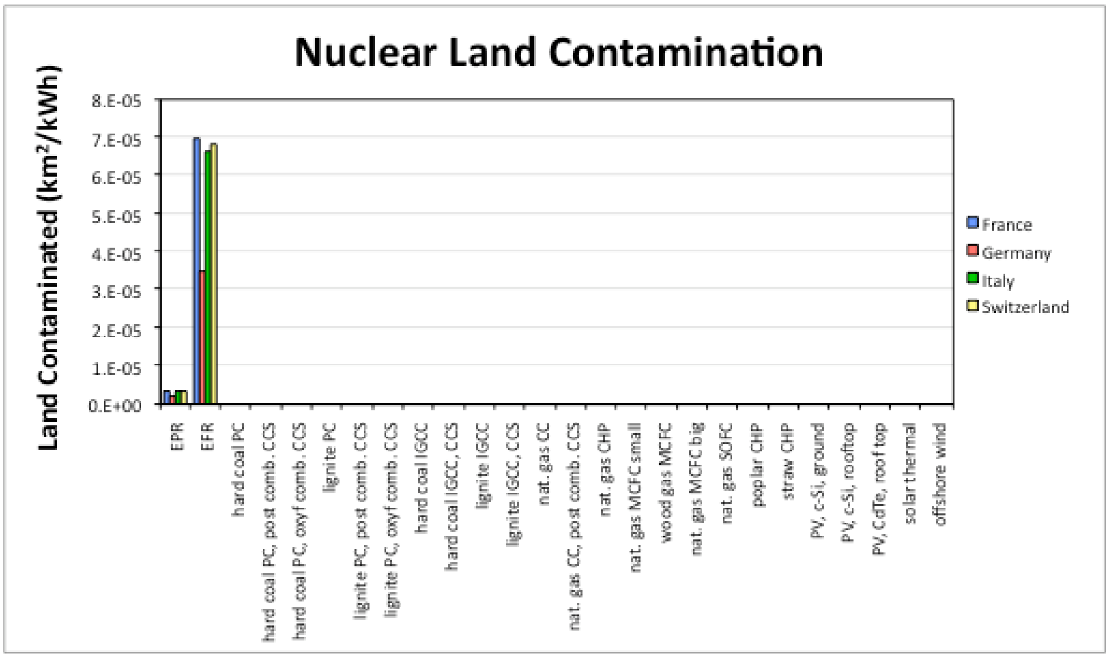


Figure 2.10 – Total Weight of Special Chemical Wastes Stored in Underground Repositories

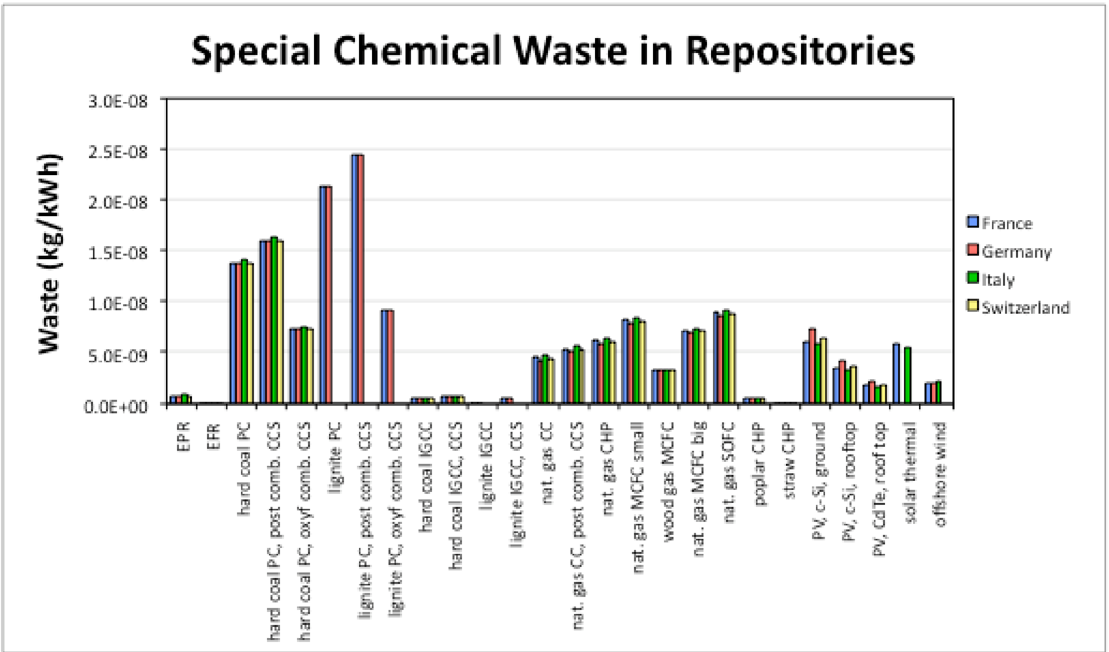


Figure 2.11 – Total Amount of Medium and High Level Radioactive Wastes to be Stored in Geological Repositories

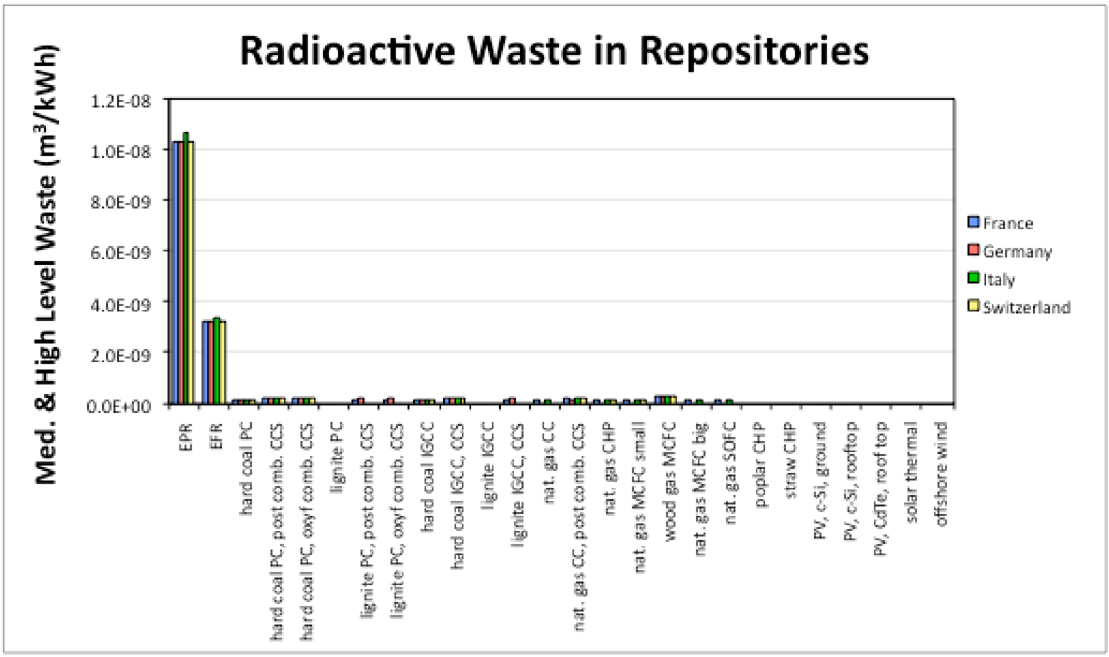


Figure 2.12 – Average Generation Cost

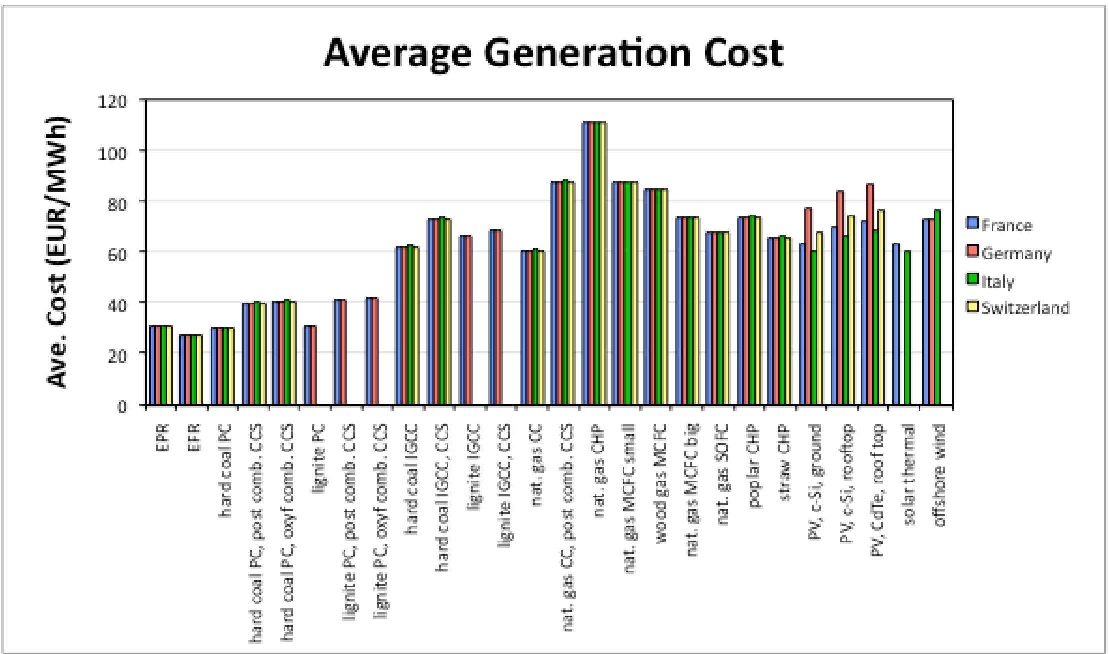


Figure 2.13 – Direct Labor

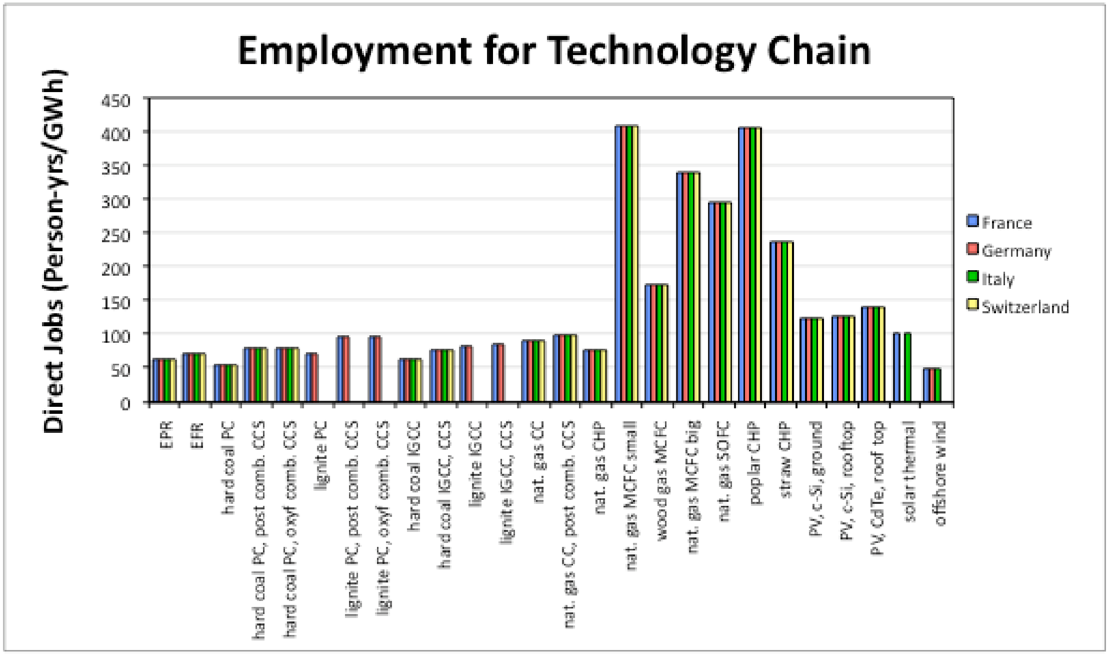


Figure 2.14 – Medium to Long Term Independence from Foreign Energy Sources

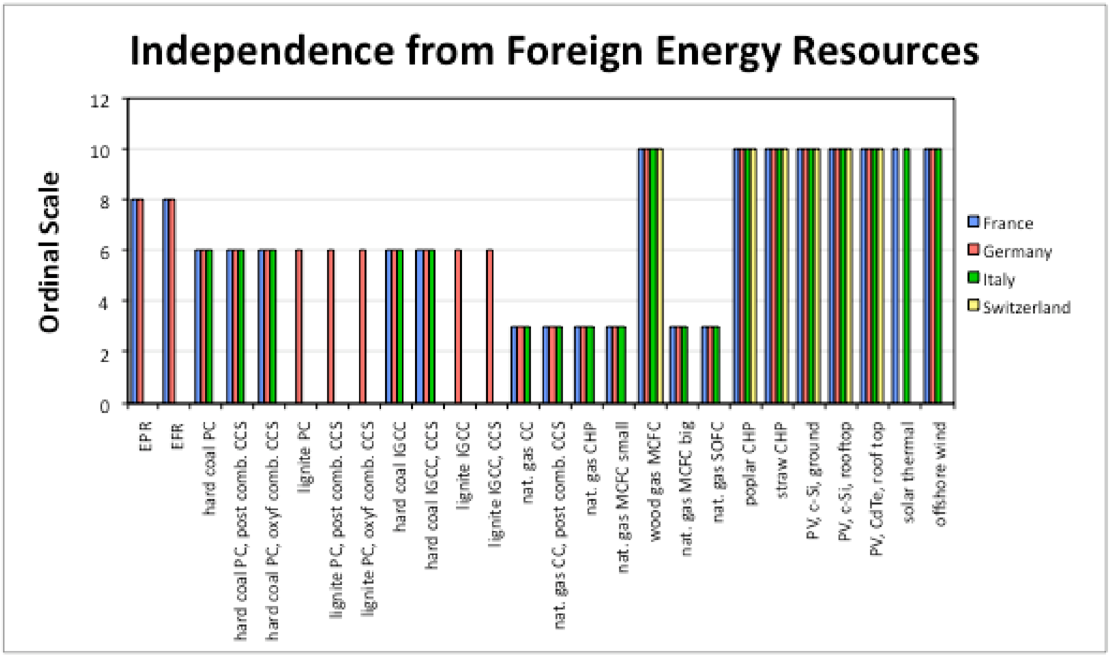


Figure 2.15 – Total Capital Cost

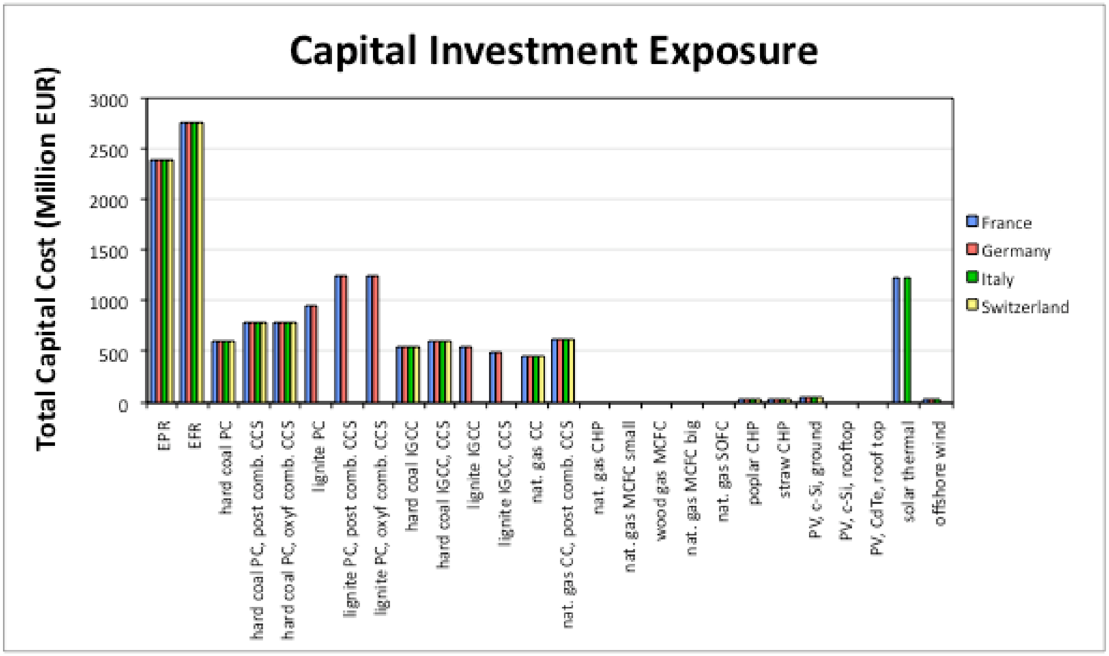


Figure 2.16 – Ratio of Fuel Cost to Generation Cost

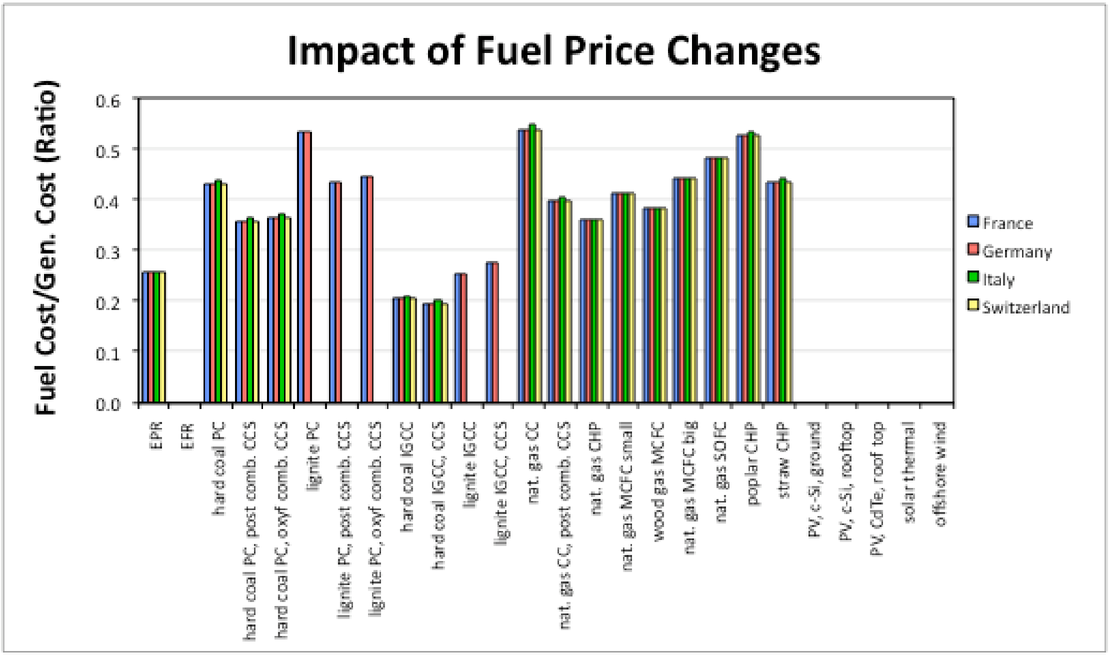


Figure 2.17 – Construction Time

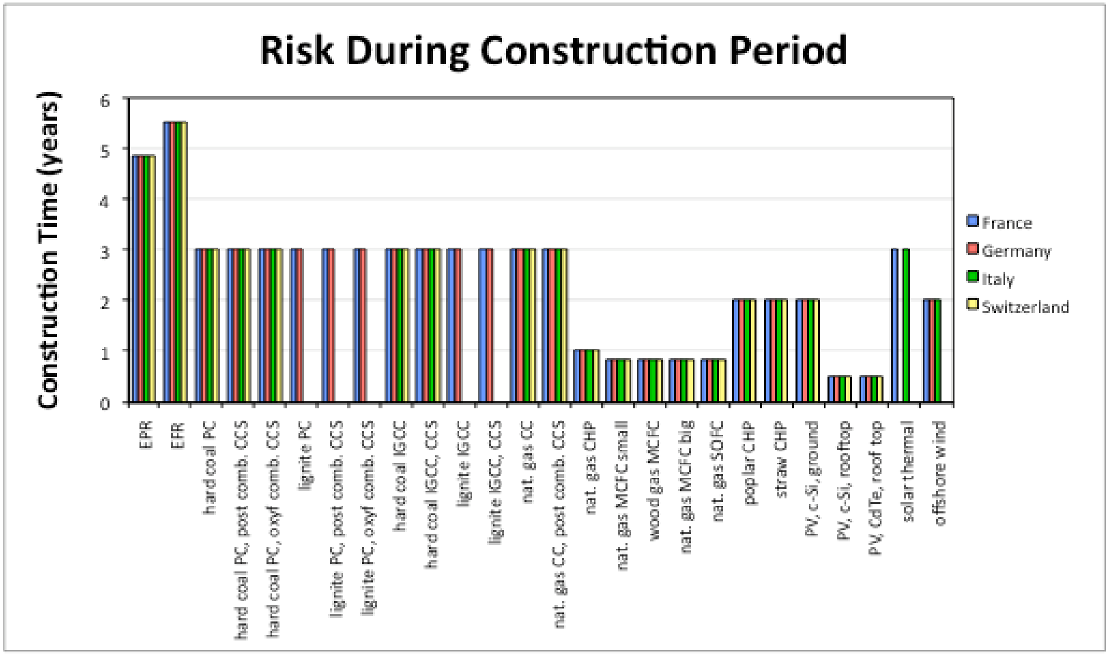


Figure 2.18 – Average Variable Cost of Generation

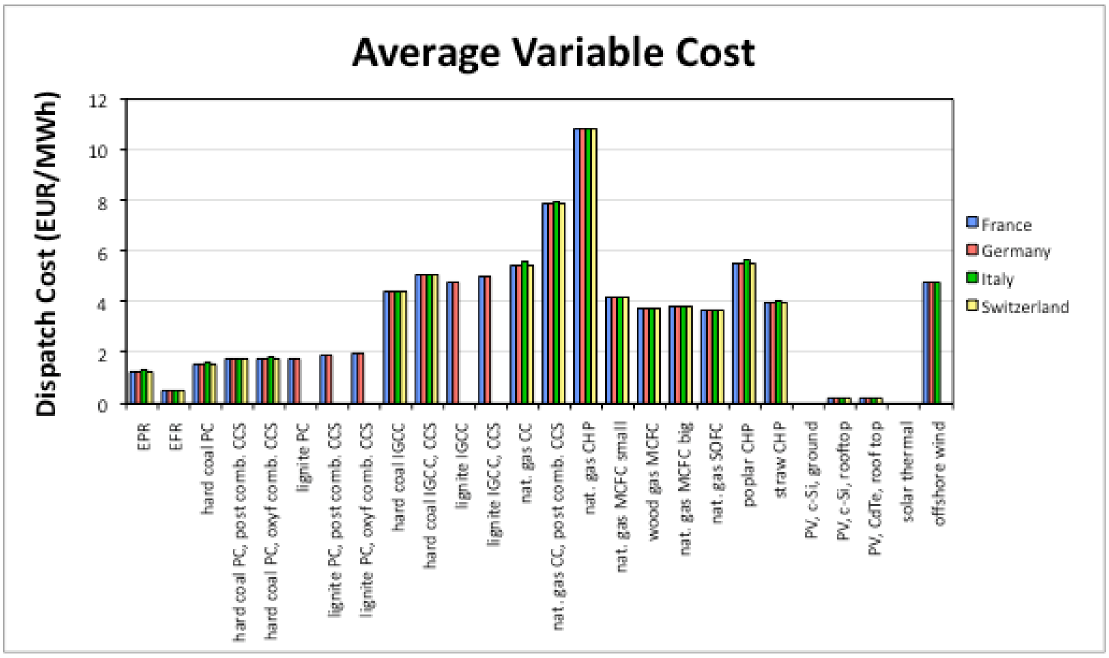


Figure 2.19 – Flexibility of Dispatch

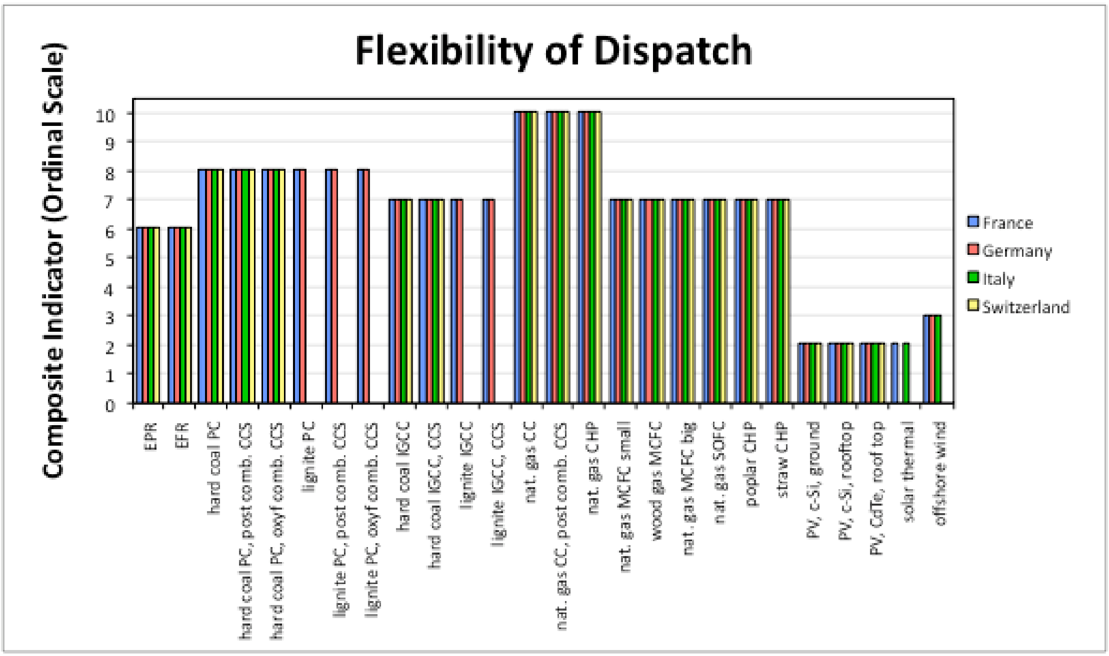


Figure 2.20 – Equivalent Availability Factor

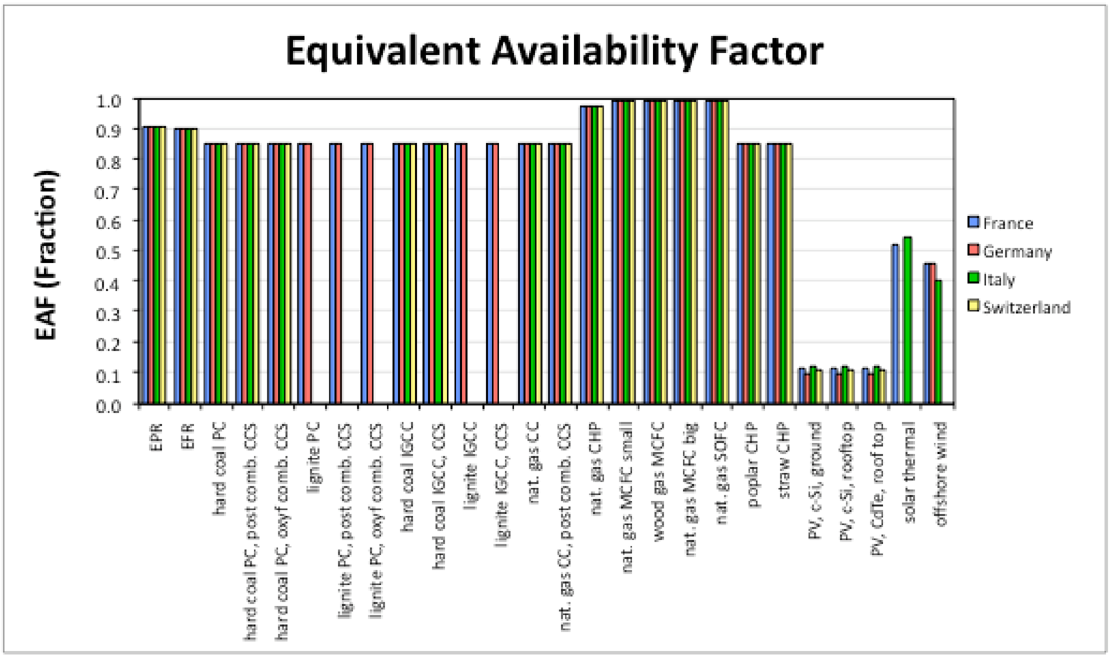


Figure 2.21 – Market Concentration in the Primary Energy Supply

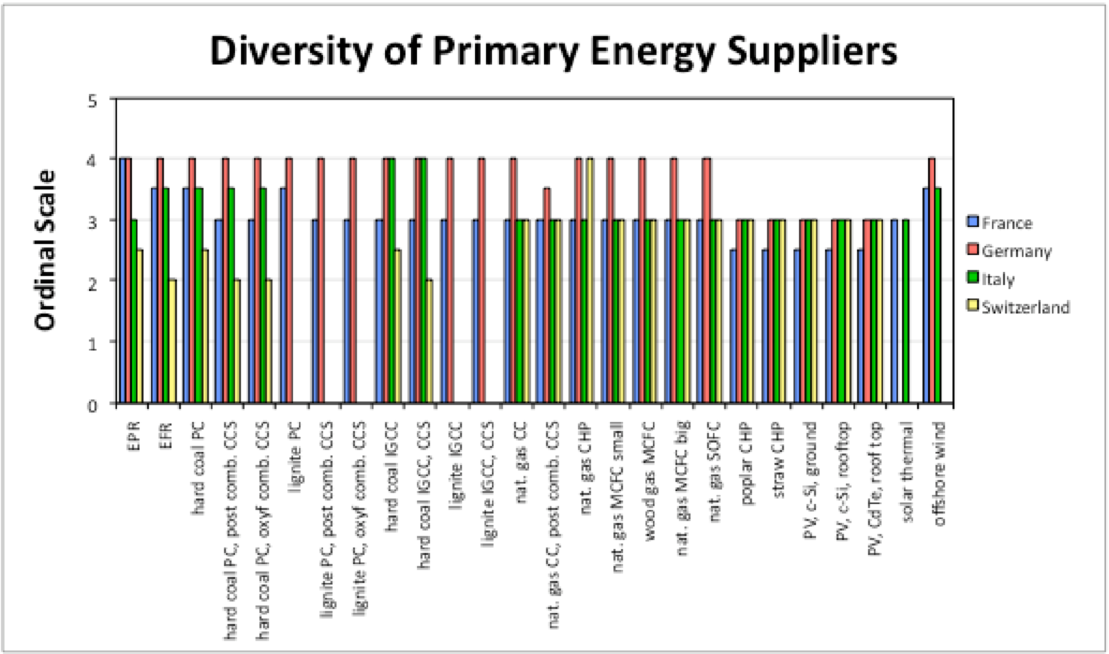


Figure 2.22 – Probability that Waste Storage Management will not be Available

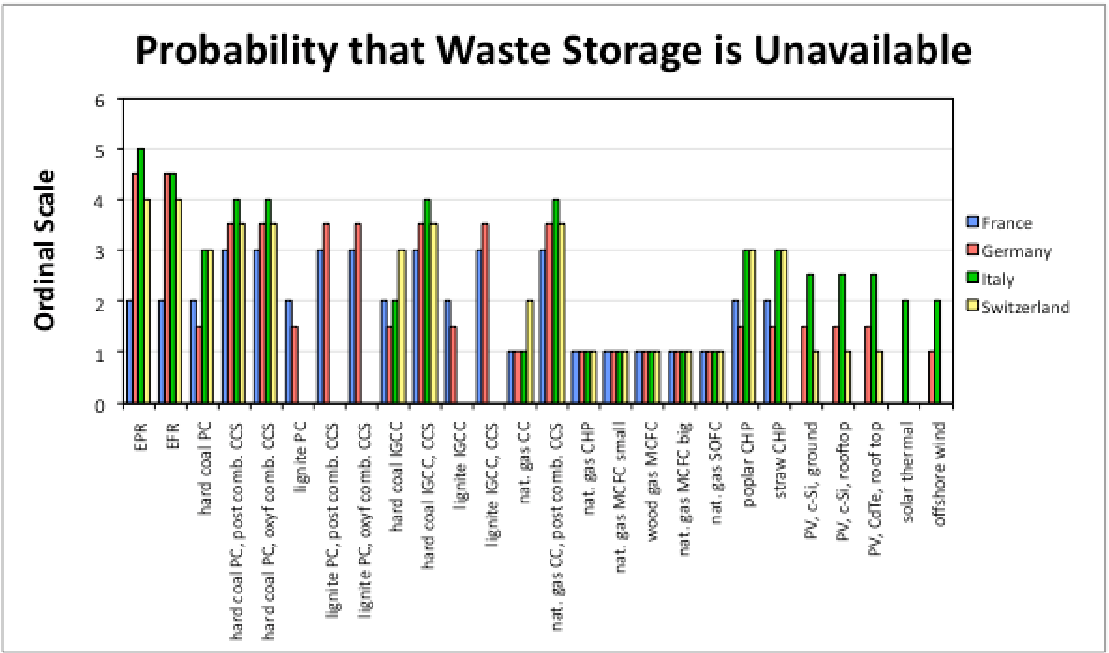


Figure 2.23 – Flexibility to Incorporate Technological Change

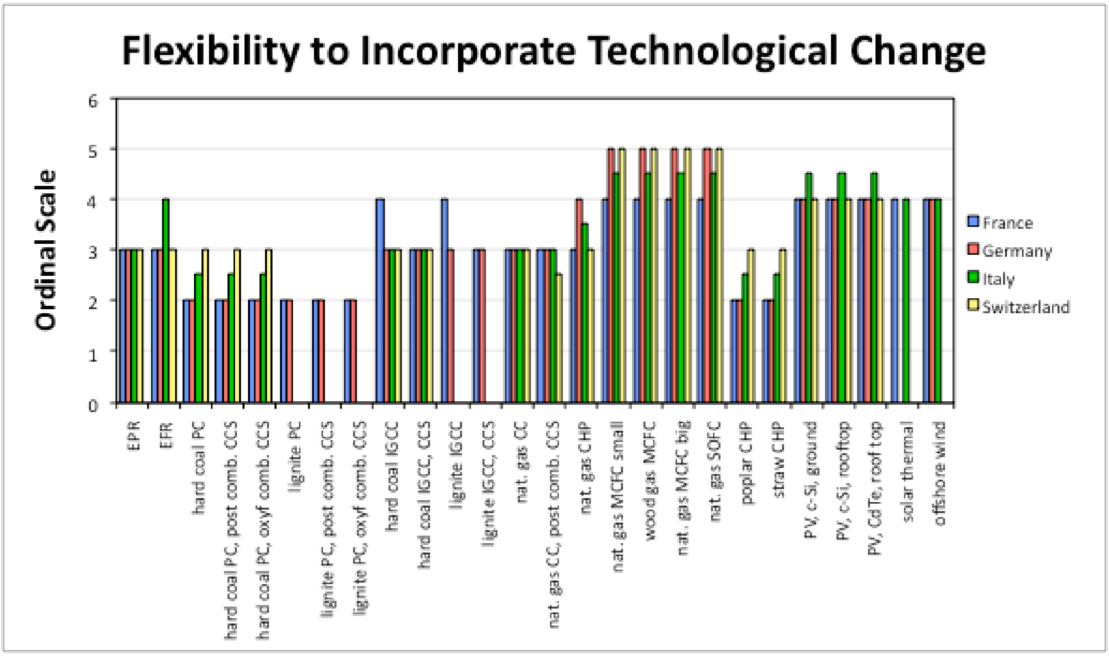


Figure 2.24 – Potential of Energy System Induced Conflicts

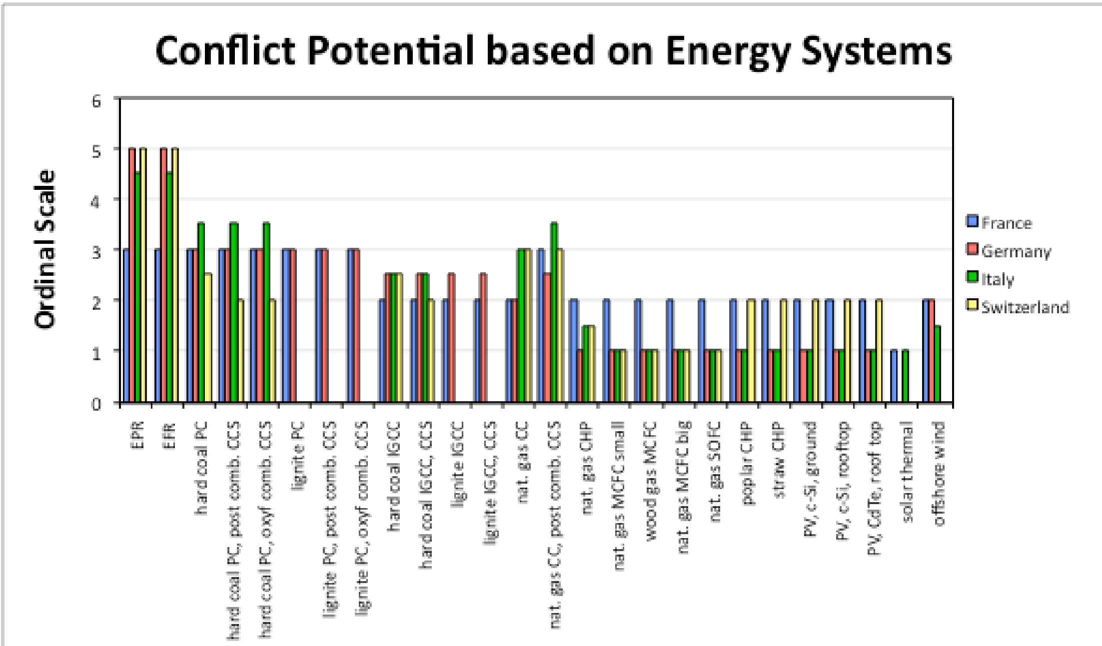


Figure 2.25 – Necessity of Participative Decision-making Processes

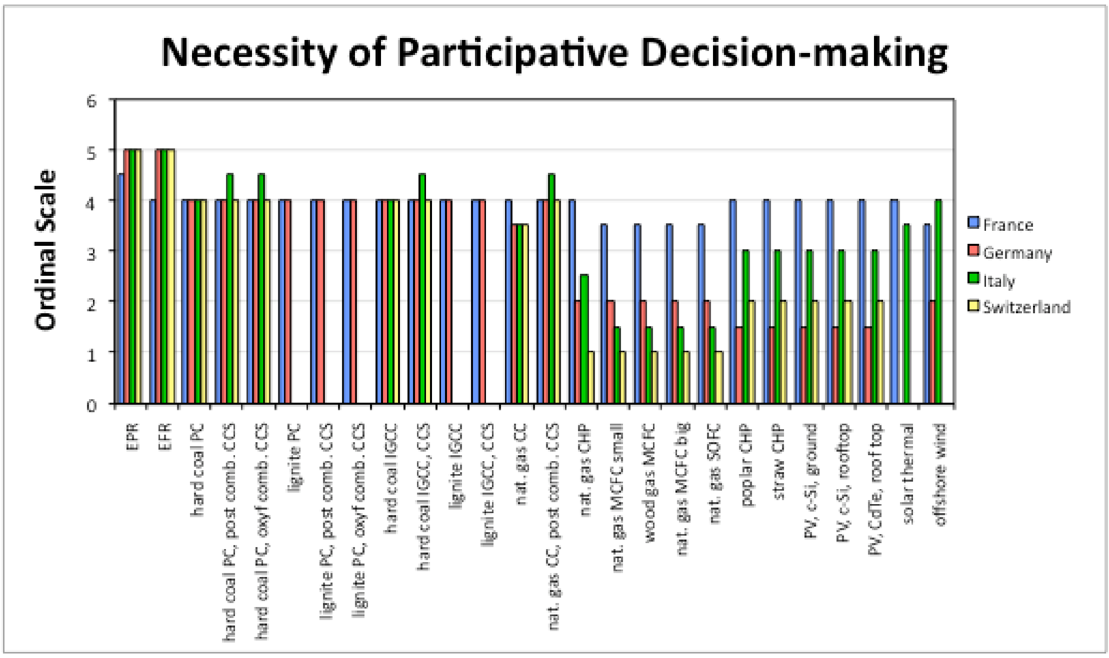


Figure 2.26 – Mortality due to Normal Operation

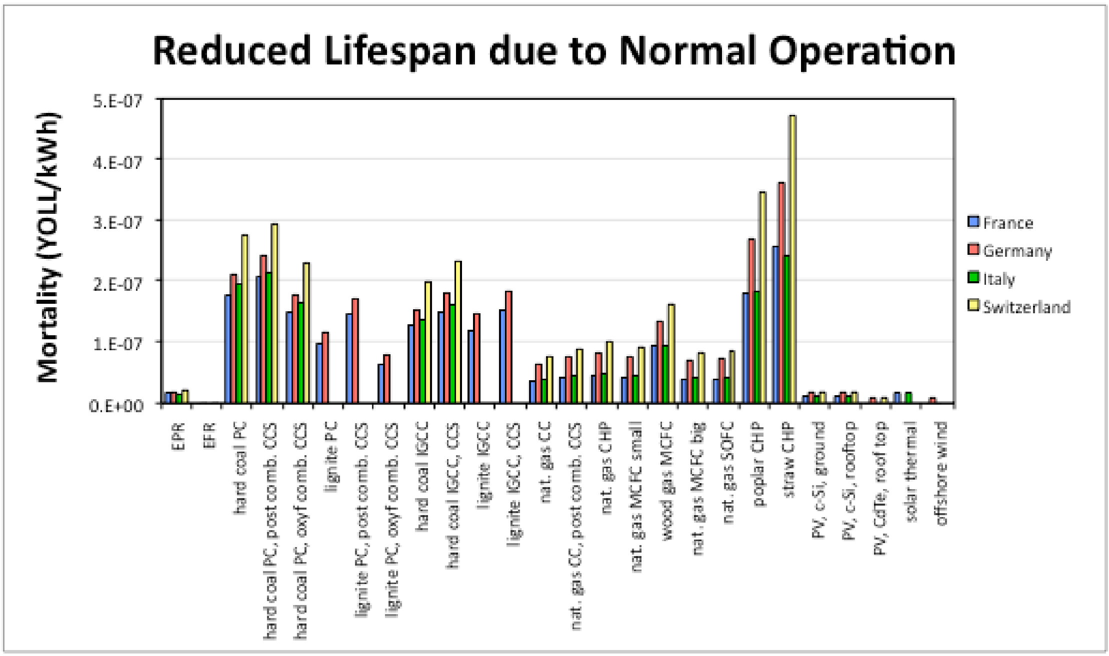


Figure 2.27 – Morbidity due to Normal Operation

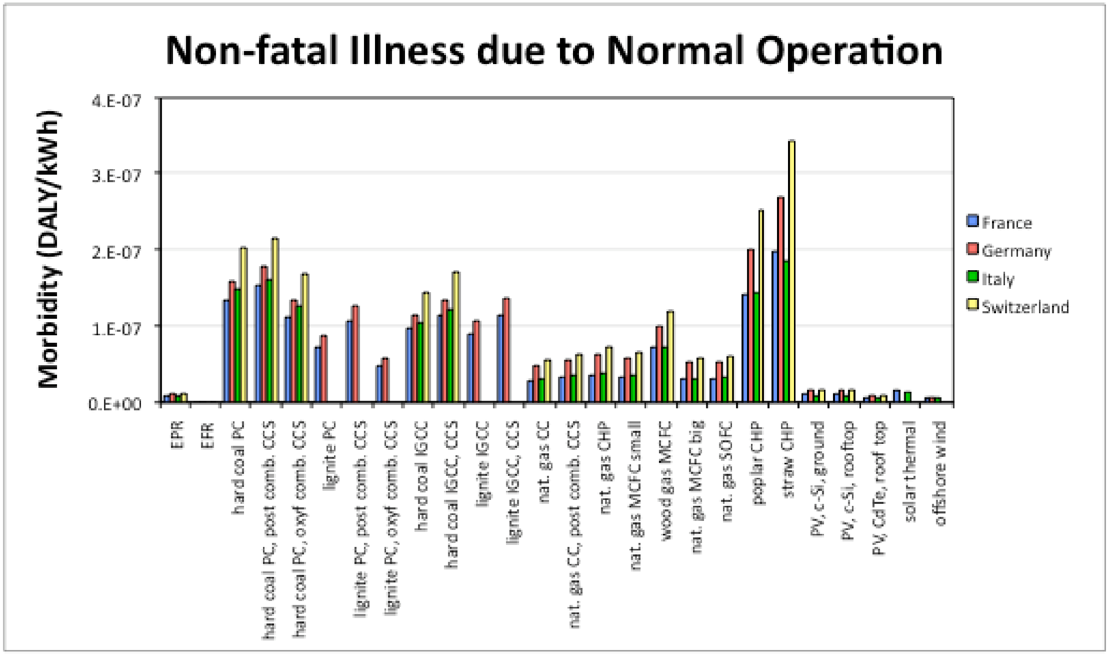


Figure 2.28 – Expected Mortality due to Severe Accidents

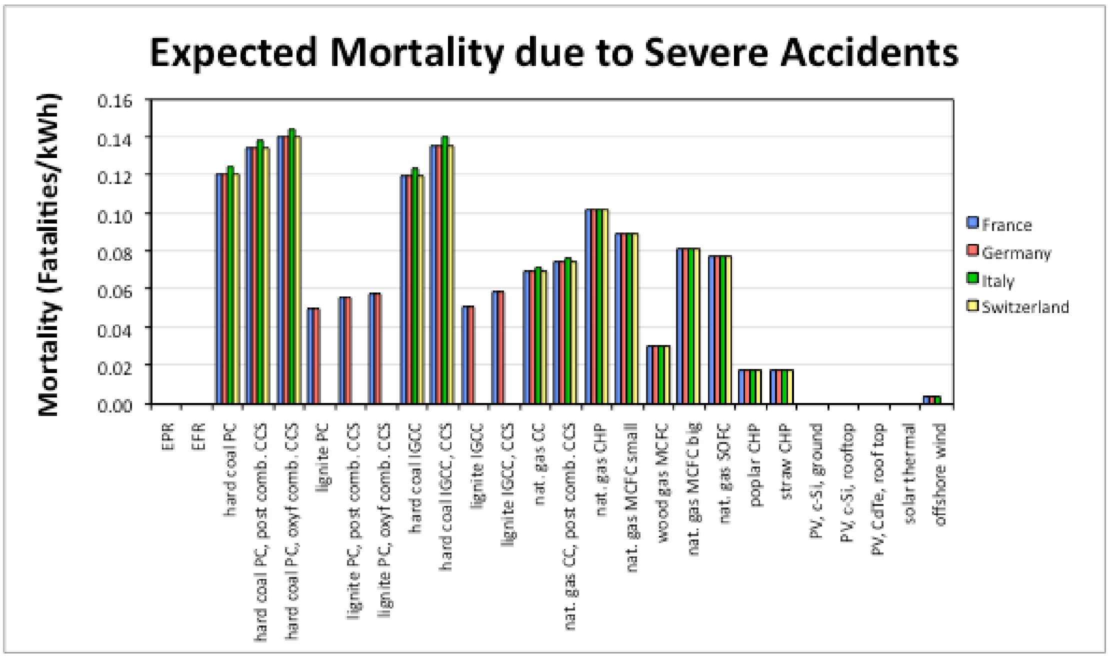


Figure 2.29 – Maximum Credible Number of Fatalities per Accident

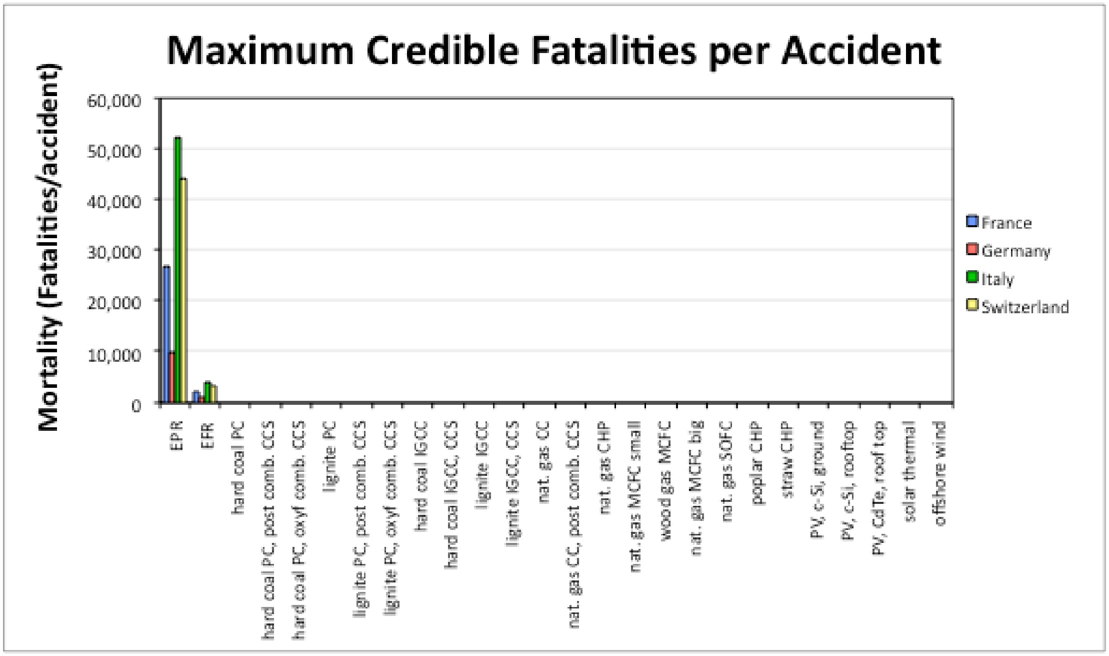


Figure 2.30 – Perceived Risk of Normal Operation

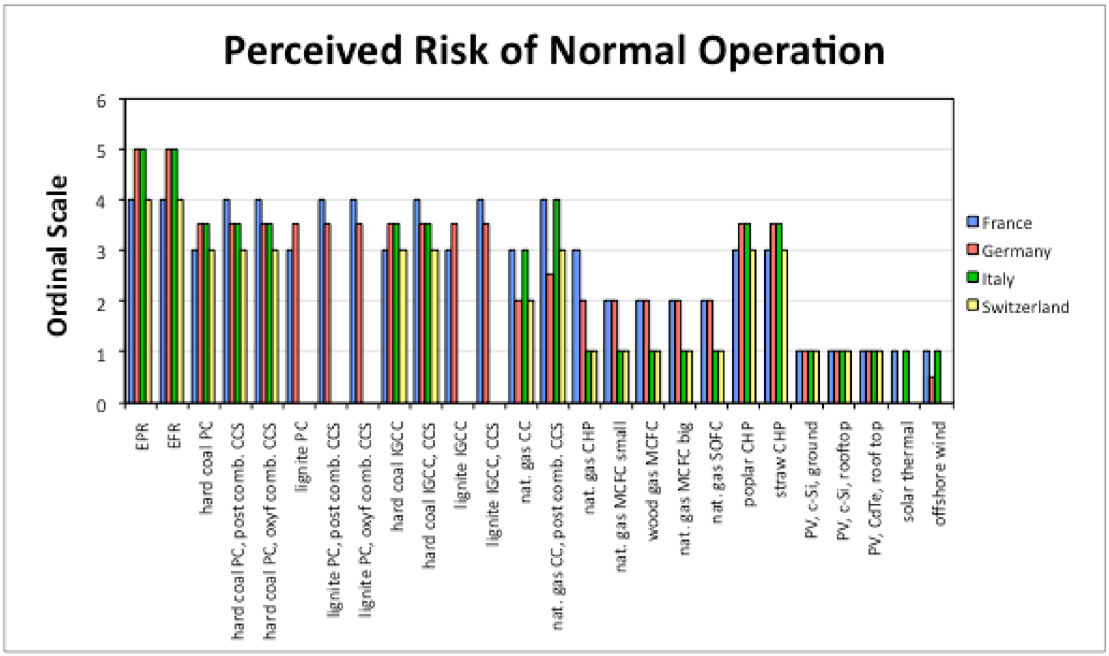


Figure 2.31 – Perceived Characteristics of Accident Risks

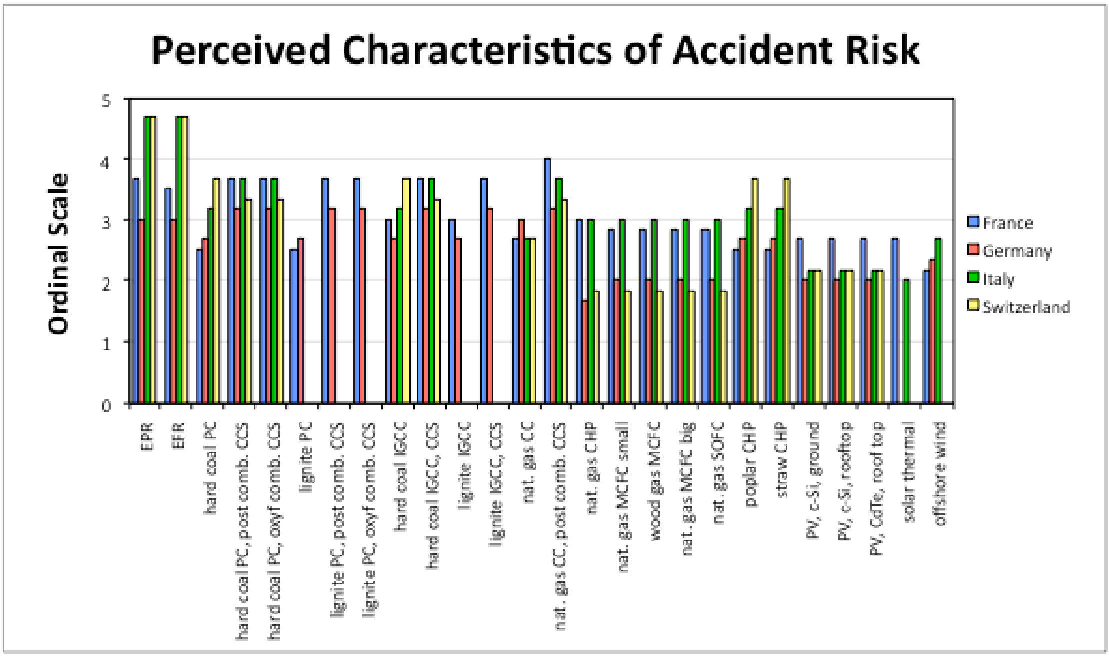


Figure 2.32 – Potential of a Successful Terrorist Attach

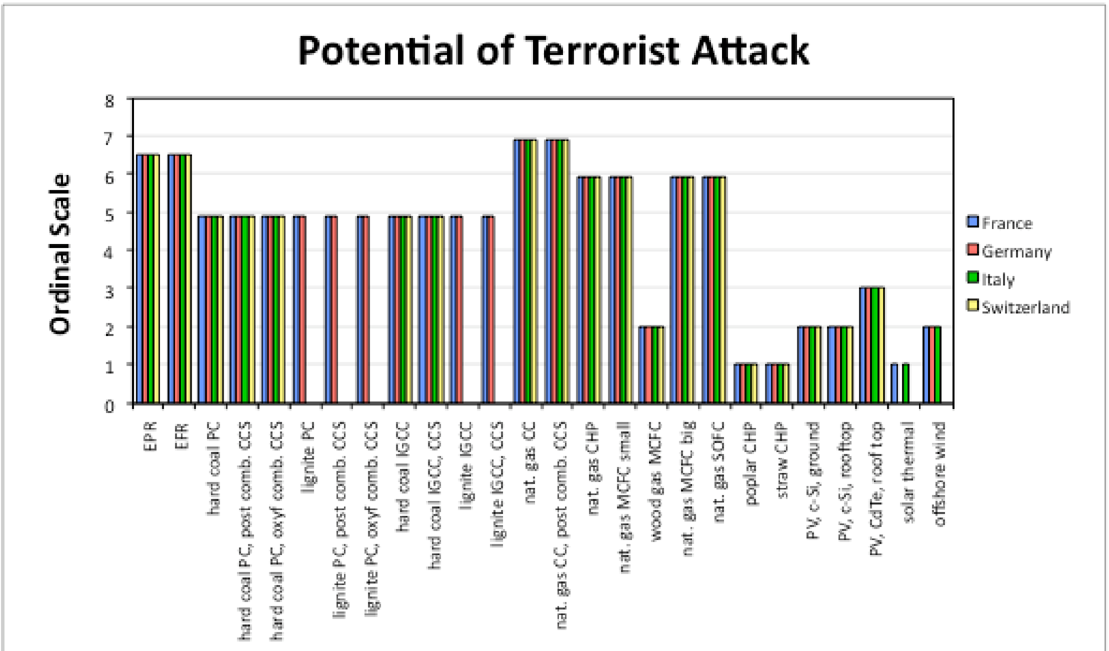


Figure 2.33 – Likely Potential Effects of a Successful Terrorist Attach

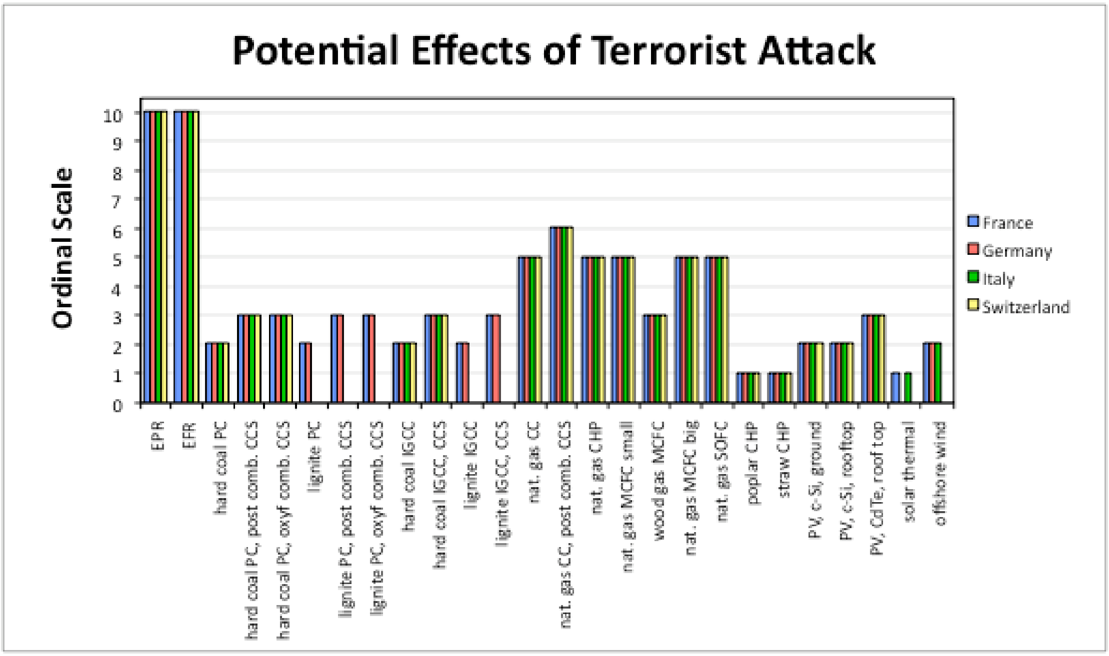


Figure 2.34 – Potential for Misuse of Technologies and Substances within the Nuclear Energy Chain

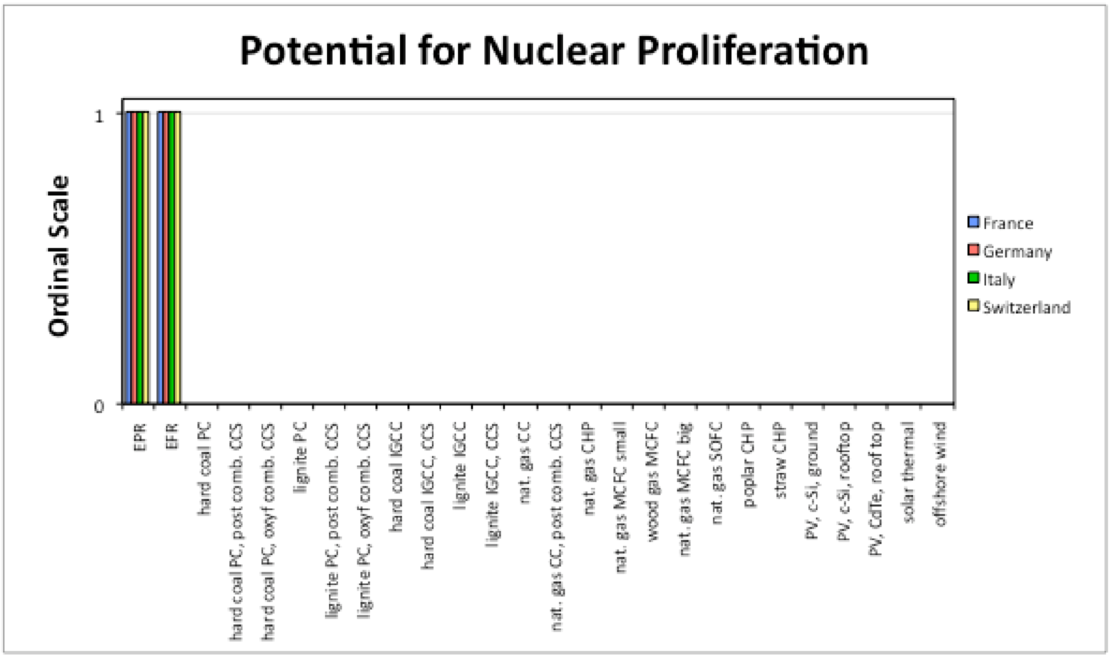


Figure 2.35 – Functional and Aesthetic Impact of Energy Infrastructure on Landscape

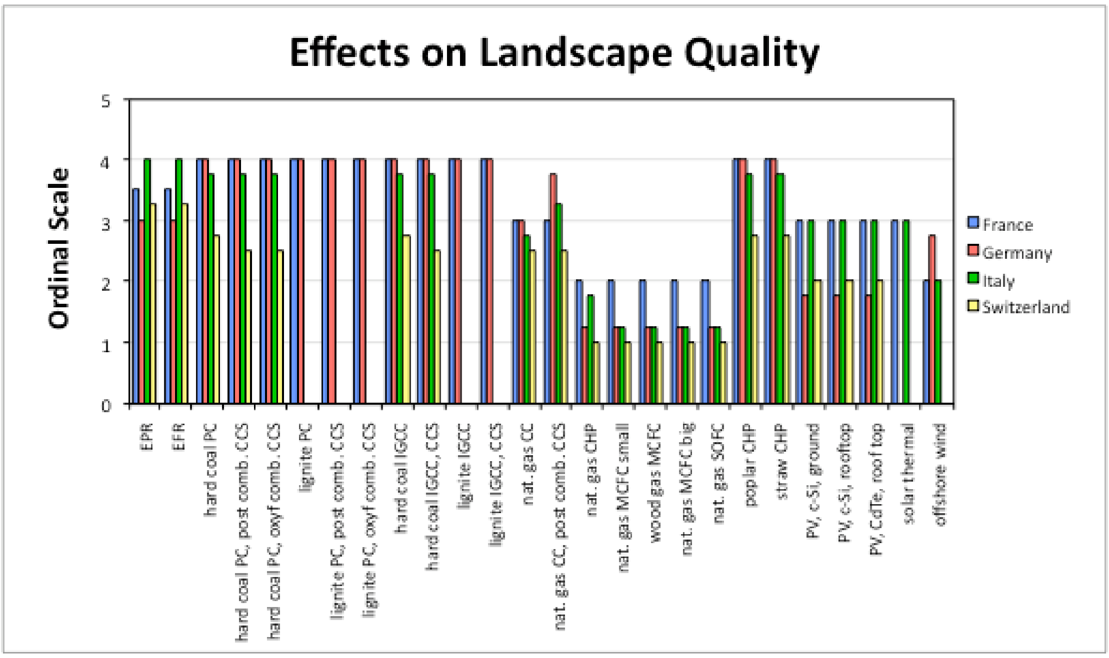


Figure 2.36 – Extent to which residents feel highly affected by noise