APPENDIX 1

CONSIDERATIONS FOR SMALL AND MEDIUM SIZED REACTORS

Based on IAEA publications and materials listed in the list of references

Revised taking into account comments from the reviewers

CONTENT

DESIGNATIONS:

AR – a consideration that could be valid for advanced NPPs indiscriminative of their unit capacity;

SMR – a consideration with a potential of being better met by reactors of smaller capacity, or the one that could be valid only for SMRs, or the one that could be more relevant to SMRs;

SRWOR – a consideration that could be valid only for Small Reactors without On-site Refuelling [4].

Note by the Scientific Secretary

With several reports on Nuclear Power Plants with Small and Medium Sized Reactors (SMRs) published by the IAEA recently [1, 2, 3, and 4], it became possible to summarize, on a preliminary basis, Considerations for such reactors. These are not user's considerations – the Considerations are based on the design and technology development status for SMRs and attempt to present a balanced and objective picture of the technical, economic and social benefits in a variety of subject areas that could be gained with NPPs based on such reactors, with a link to certain design and technology and infrastructure developments considered in member states to achieve such advantages, with a link to different groups of stakeholders.

Each of the considerations given in the tables below could be attributed to several SMRs described in references [3 and 4]; however, taken on the whole, the considerations cannot be viewed as a single consistent set; in other words, there are no single SMR that will meet all the considerations.

Generically, it is up to different groups of stakeholders (e.g., the international community, users, vendors, investors, etc.) to make a selection from or judgement upon the presented Considerations.

On a scrutiny of the considerations it may appear that the set as a whole addresses mainly the users in those countries, which currently either do not have, or have a small size of nuclear infrastructure, and are contemplating either induction, or significant expansion of nuclear power for the first time. However, this is not the case – most of the innovative SMR designs are meant for a broad variety of applications in the developed and developing countries alike, no matter whether they have already embarked on a nuclear power programme or are only planning to do so [3 and 4].

Also, it is important to note that small or medium sized reactor does not necessarily mean small or medium sized nuclear power plant. Plants with SMRs could be built several at a site. Many of SMR concepts and designs described in [3 and 4] provide for NPP configurations with 2, 4, or even more reactor modules. In some cases, the modules could be added incrementally, allowing to minimize Capital-at-Risk.

Finally, it should be emphasized that SMRs are not the only prospective nuclear option; nearly all designers recognize that a diverse portfolio of reactors of different capacity and applications would be needed if nuclear power is to make a meaningful contribution to global sustainable development.

The anticipated role of SMRs in global nuclear energy system could then be to increase the availability of clean energy in usable form in all regions of the world, to broaden the access to clean and affordable and diverse energy products and, in this way, to contribute to the eradication of poverty and, subsequently, to peace and stability in the world.

In the course of the review process of Considerations, a suggestion was produced that potential users of SMRs could be classified in several categories, based on a combination of the following parameters:

a. Current size of the grid (small, medium, large);
b. Size of the current nuclear infrastructure (small, medium, large);
c. Projected energy needs (small, medium, large) in different time frames (near-, mid- and long-terms) and expected share of the nuclear;
d. Population density and availability of sites for nuclear facilities (small, medium ,large);
e. Domestic availability of and/or accessibility (from international sources) to nuclear fuel (uranium and thorium, separately) – (small, medium, large);
f. An assessment of degree of conservatism to be exercised in respect of implementation of proliferation resistance measures with a linkage to technology (small, medium, large).

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(I) Considerations relevant to the international community

#	Consideration / Subject Area of Relevance	Application range/ Reference
	I.1. Safety	
I.1.1	Enhanced level of safety, consistent with the scale of global deployment of power reactors, through strong reliance on inherent and passive safety features and reliable passive systems, lower source terms, smaller quantities of stored heat, and lower decay heat generation rates[1]	AR - SMR/ [1, 3, 4]
	I.2. Carbon Emissions and Climate Change	
I.2.1	Electricity generation without greenhouse gaseous emissions and harmful exhausts and cogeneration options with flexible or multiple non-electric applications, to minimize not only the emissions associated with electricity generation but also those arising from the heat and motive power production by fossil fuel combustion	AR - SMR/ [3]
	I.3. Proliferation Resistance	
I.3.1	Proliferation resistance explicitly addressed in the plant design	AR/ [3]
I.3.2	An overall reactor and fuel cycle activity that is proliferation resistant, e.g., with limited overall amount of fissile material, high degree of contamination providing noticeable radiation barriers, fuel forms that are difficult to reprocess and/ or types of fuel that make it difficult to extract weapons-grade fissile material	AR - SMR/ [1, 4]
I.3.3	Difficult unauthorized access to fuel during the whole period of its presence at the site and during transportation, and design provisions to facilitate the implementation of safeguards	AR - SRWOR/ [1, 4]
I.3.4	Minimum inventory of fresh and spent fuel being stored at the site outside the reactor during its service life	SMR - SRWOR/ [1, 4]
I.3.5	Absence of refuelling equipment on the site and elimination of the on-site fresh and spent fuel repositories.	SRWOR/ [4]
I.3.6	Possibly greater or easier non-proliferation assurances to the international community in the case when all fuel loading/ unloading operations are either outsourced to a factory in the supplier-country or centralized/regional facility or whole core refuelling is conducted infrequently at a site by vendor crews using equipment brought to the site and removed with the used core.	SMR - SRWOR/ [4]

[1] While with the larger size reactor with adequate implementation of inherent and passive safety features, it may be possible to bring down core damage frequency to levels consistent with those in any SMRs with appropriate safety features, the consequence of an accident of same probability occurring in a large size reactor are likely to be high on account of potentially larger source term, larger quantity of stored heat and also larger decay heat generation rates. As such, for meeting a stringent, technology neutral, quantitative probabilistic safety considerations, which have to be in place before the large range and variety of NPPs can be deployed on a large scale, the choice of a SMRs could appear to be more preferable than a larger size plant.

(I) Considerations relevant to the international community (continued 1)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	I.3. Proliferation Resistance (continued)	
I.3.7	Item accountancy on entire cores during shipment and operation deployment of such reactors (for factory fabricated and fuelled reactors designed for operation with weld-sealed reactor vessel)	SRWOR/ [4]
	I.4. Fuel Cycle Arrangements	
I.4.1	Centralized, e.g., regional, fuel cycle services, perhaps, under an international oversight	AR/ [1, 3]
I.4.2	All fuel loading/ unloading operations are either outsourced to a factory in the supplier-country or centralized/regional facility, or whole core refuelling is conducted infrequently at a site by vendor crews using equipment brought to the site and removed with the used core.	SMR - SRWOR/[1, 4]
	I.5. Legal and Institutional	
I.5.1	Harmonized industrial standards/codes and regulatory rules/procedures	AR/ [1]
I.5.2	Reciprocity arrangements among licensing authorities in user and vendor countries or an international safety design acceptance regime	AR/ [1, 4]
I.5.3	Provisions for competitive and comprehensive fuel cycle service agreements	AR/ [3]
I.5.4	Assurance of fuel supply and take back, including technological 'assurance' via long operating interval between refuellings	AR - SRWOR/ [1, 4]
I.5.5	Provision of the internationally secured guarantees of sovereignty to those countries that would prefer to buy or lease fuel for their NPPs from outsourced vendors	AR / [1, 4]
I.5.6	Legal and institutional provisions for the creation and operation of multinational fuel cycle facilities[2]	AR / [1, 4]
I.5.7	Institutional arrangements to facilitate future transition to a sustainable symbiotic fuel cycle, including institutional provisions for transfers of transuranic-containing reload fuel across national borders	AR - SRWOR/ [4]
I.5.8	Option of NPP leasing or a power purchase contract with the plant owned and operated by a foreign national or a multinational generation company	SMR/ [3]
I.5.9	Legal and institutional provisions for reactor module or NPP leasing	SMR/ [1, 3]

[2] International fuel cycles could, probably, be created on a regional or interregional basis, perhaps starting from international repositories of waste.

(I) Considerations relevant to the international community (continued 2)

#	Consideration / Subject Area of Relevance	Application range/ Reference
	I.5. Legal and Institutional (continued)	
I.5.10	Provision of liability and insurance arrangements for the transit of fresh and spent whole-core fuel loads and/or factory fabricated and fuelled reactors through the territory of a third country	SRWOR/[1, 4]
	I.6. Global Sustainability of Nuclear Power	
I.6.1	An overall reactor and fuel cycle enterprise that contributes to effective use of the resources in a sustainable way[3]	AR/ [1, 3, 4]
I.6.2	Flexible fuel cycle options, e.g., once-through use or recycling of U, Pu or/ and Th fuel	AR/ [3]
I.6.3	Energy architecture that extensively distributes nuclear power plants but at the same time centralizes fuel cycle support services to a small number of locations for conducting bulk fissile handling operations in the economy-of-scale facilities and under appropriate safeguards oversight.	AR/ [1,3, 4]
I.6.4	A variety of applications, including generation or flexible co-generation of electricity, production of heat, potable water, process steam, or hydrogen, etc.	SMR/ [1, 4]
I.6.5	An energy architecture in which many fast neutron spectrum reactors and, possibly some thermal spectrum reactors with ^{233}U-Th fuel are designed to be fissile self-sufficient through recycling in a closed fuel cycle but with fuel breeding excluded by design (breeding ratio of about 1), with deployments of such reactors being configured to share a common symbiotic fuel cycle with current and near-term deployments of reactors based on a once-through cycle [4]	SRWOR/[1, 4]

[3] Effective resource utilization may be a matter of many factors, such as material intensity of the reactor design, neutron economy, fuel burn-up, power density, energy conversion efficiency and, last but not least, the recycling.

[4] The integrated symbiotic fuel cycle could be one wherein spent fuel from once-through (open) cycle near-term concepts will be reprocessed to serve as a feedstock to fuel initial working inventories of longer-term closed fuel cycle concepts.

(U) Considerations relevant to the user

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	U.1. Economics and Financial Risks	
U.1.1	Proveness of the basic NPP technologies[5]	AR/ [3]
U.1.2	Smaller upfront capital investments matching the investment capability of the user	SMR/ [1,3, 4]
U.1.3	Incremental capacity increase through modular approach with a staggered build of reactor modules, enabling to achieve economic benefits from the learning curve, to reduce the present value capital cost per kW(e) installed, and to minimize the upfront investments and the "capital-at-risk".	SMR/ [3, 4]
U.1.4	Simplified and economical operation and maintenance, and lower infrastructure investment required, owing to certain accident initiators/consequences being eliminated/prevented by the design with a corresponding reduction in the safety systems	SMR/ [3, 4]
U.1.5	Higher energy conversion efficiency and/ or purposeful use of the reject heat to improve plant economy	SMR/ [1, 3, 4]
U.1.6	An option of leasing the complete nuclear steam supply system, e.g., with the balance of plant being built by the user – "pay as you go" alternative to the outright purchase of the complete plant	SMR/ [1, 4]
U.1.7	Minimum reliance on complex local infrastructure, to minimize infrastructure emplacement requirements and associated costs	SMR/ [1, 4]
U.1.8	The flexibility of an offered plant in power range, siting, fuel cycle options, and applications with a option to tailor it rapidly to the demands of an individual customer	SMR/ [1,3, 4]
U.1.9	Reduced risk insurance cost due to lower probability x consequences of severe accidents	SMR – SRWOR/ [3, 4]
U.1.10	An option of fuel leasing to secure lower investment costs and risks for the customer – "pay as you go" alternative to outright purchase of the fuel	AR – SMR - SRWOR/ [1,3, 4]
U.1.11	The overall energy cost minimized resulting from an optimized fuel cycle cost as well as the NPP cost, relying on finding an optimum combination of the NPP system and the associated fuel cycles	AR - SRWOR/ [1, 4]

[5] The requirement of technology proveness does not mean that design configuration of a plant cannot be innovative; there are examples when users accept FOAK plants in their countries on condition that they are licensed in a vendor country; moreover, it is generically anticipated that the vendor could offer a partnership and attractive conditions to the user who would agree to buy an innovative FOAK plant.

(U) Considerations relevant to the user (continued 1)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	U.2. Local Participation and Technology Transfer	
U.2.1	Increased local participation in NPP construction to reduce overnight capital costs	SMR/ [3, 4]
U.2.2	Option of local manufacturing of the reactor and NPP components secured by a simplicity and size of the design, matching the capabilities of the local industry and offering a potential for its upgrading	SMR/ [5]
U.2.3	Limited or no nuclear safety function assigned to the balance of plant, so that it could be built to local standards by local constructors using local labour with financing denominated in local currency	SRWOR/ [1, 4]
U.2.4	Provisions for local collaboration in First-of-a-Kind design, engineering, and licensing	AR - SMR / [3]

(U) Considerations relevant to the user (continued 2)

#	**Consideration/ Subject Area of Relevance**	**Application range/ Reference**
	U.3. Siting	
U.3.1	Reduced or eliminated off-site emergency planning requirements, resulting in an enhanced economic viability and improved public acceptance	SMR/ [1,3, 4]
U.3.2	A variety of options for siting, including those close to population or power consumption centres, as well as remote and hardly accessible areas, dispersed islands, etc	SMR - SRWOR/ [1,3, 4]
	U.4. Construction, Operation, Maintenance, and Decommissioning	
U.4.1	Supply of a standard pre-licensed turnkey plant delivered and assembled by a skilled vendor team with only a short interval between securing financing and the start of a revenue stream	AR - SMR/ [3, 4]
U.4.2	Shorter construction period and higher manufacturing quality achieved through factory mass production, design standardization, equipment unification and common basis for design certification	SMR/ [1, 4]
U.4.3	Simplified operation procedures and robustness with respect to human errors, e.g., due to certain accident initiators/consequences eliminated/prevented by the design with a corresponding reduction in the safety systems	SMR/ [1,3, 4]
U.4.4	Reactor sized for transportability (or transportability of the modules)	SMR/ [1,3, 4]
U.4.5	Extended operational cycle (infrequent refuelling)	SMR - SRWOR/ [3, 4]
U.4.6	Factory fabrication and fuelling to facilitate delivery of a sealed core to the plant site for a direct installation	SRWOR/ [1, 4]
U.4.7	All fuel loading/ unloading operations are conducted infrequently at a site by vendor crews using the refuelling equipment brought to the site and removed with the used core.	SRWOR/ [1, 4]
U.4.8	A cost-effective decommissioning strategy in which the disassembling and all subsequent operations with a reactor module or a NPP are outsourced to a centralized factory, and which would benefit from the absence of fresh and spent fuel storages at the site.	SRWOR/ [4]

(U) Considerations relevant to the user (continued 3)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	U.5. Waste Management and Environment	
U.5.1	Clearly defined strategies of spent nuclear fuel and waste management	AR/ [3]
U.5.2	Reduced waste from maintenance due to certain accident initiators/consequences eliminated/prevented by the design with a corresponding reduction in the safety systems	SMR/ [3, 4]
U.5.3	Reduced obligations of the user for spent fuel and waste management when all fuel loading/ unloading operations are either outsourced to a factory in the supplier-country or centralized/regional facility, or whole core refuelling is conducted infrequently at a site by the vendor crews using the refuelling equipment brought to the site and removed with the used core.	SRWOR/ [1, 4]
	U.6. Plant Security and Sabotage Protection	
U.6.1	Reactor and plant design inherently eliminating the possibility or decreasing the consequences of human actions of malevolent character, including the insider threat	AR - SMR/ [3]
	U.7. Infrastructure Requirements	
U.7.1	Simplified licensing procedures, e.g., reduced or eliminated off-site emergency planning and simplified licensing of a replicate plant construction	SMR/ [1, 3, 4]
U.7.2	Reduced operating staff number and required skill level through plant simplification achieved owing to certain accident initiators/consequences being eliminated/prevented by the design with a corresponding reduction in the safety systems	SMR/ [1, 3]
U.7.3	Legal and institutional provisions for fuel leasing	AR - SRWOR/ [1, 4]
U.7.4	Legal and institutional provisions for reactor module or NPP leasing	SMR - SRWOR/ [1,3, 4]
	U.8. Energy Needs and Energy Security	
U.8.1	Increased NPP service life	AR/ [3]
U.8.2	Flexible siting, applications, and fuel cycle options	AR - SMR/ [1, 3, 4]
U.8.3	Technological 'assurance' of fuel supply and take back via a long refuelling interval and operation without on-site refuelling[6]	SRWOR/ [1, 4]

[6] To relax the dependence on foreign suppliers, fuel cost changes, political and economic tensions and conflicts between countries, etc. – altogether increasing energy security to the user.

(U) Considerations relevant to the user (continued 4)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	U.9. National Sustainable Development	
U.9.1	Smaller upfront capital investments matching the current investment capability of the user	SMR/ [1,3, 4]
U.9.2	Option of incremental capacity increase through modular approach with a staggered build of reactor modules, enabling to match the growth in energy demand	SMR/ [1,3, 4]
U.9.3	A variety of non-electrical applications to satisfy dynamic and diverse demands of the user, including generation or co-generation of electricity, production of heat, potable water, process steam, or hydrogen; with a high degree of flexibility provided by the plant design	SMR/ [1,3, 4]

(V) Considerations relevant to the vendor/ vendor and regulator[7]

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	V.1. Safety Design	
V.1.1	Safety design eliminating the possibility of accidents from occurring rather than dealing with their consequences, thus significantly improving the defence-in-depth and safety characteristics	SMR/ [1, 3]
V.1.2	Radiation exposure to the general public set at 10^{-7}-10^{-8}/year probability of exceedence in recognition of the source term comparable to facilities without a potential for core melt or combustion, to enable siting near the populated centres.	AR - SMR/ [2, 3]
V.1.3	External events considered from the early stages of the reactor design[8]	AR/ [2]
V.1.4	Capability to withstand all postulated accident scenarios, including those caused by natural or human-induced external events, without requiring emergency response actions	SMR/ [1,3]
V.1.5	Increased grace period, so that even in the event of failure of active safety systems safety is ensured with no external power and water supply and operator intervention over a long period, reaching several days or more.	AR/ [3, 4]
V.1.6	Provision of a passive in-vessel retention of corium or exclusion of core melting	AR - SMR/ [3]
V.1.7	Refractory fuel forms or/and structural materials with provision of a large margin to fuel failure and of the perfect retention of fission products at high temperatures	AR - SMR/ [1]
V.1.8	Capability to survive all postulated accident scenarios, including those caused by natural or human-induced external events without compromising the transportability of the reactor back to the manufacturers	SRWOR/ [1, 4]
V.1.9	An autonomous or semi-autonomous passive load follow feature such that no conceivable combination of multiple equipment and human errors occurring outside the reactor vessel could lead to core damage	SRWOR/ [4]
	V.2. Design for Proliferation Resistance and Plant Security	
V.2.1	Proliferation resistance explicitly addressed in the plant design	AR/ [3]
V.2.2	Reactor and plant design inherently eliminating the possibility or decreasing the consequences of human actions of malevolent character, including the insider threat[9]	AR - SMR/ [3]

[7] Vendors would generically benefit from taking into account as many considerations important to the users and the international community (see Tables U and I) as possible. To minimize repetitions, Table V repeats only those considerations that might require a closer interaction among vendors and users to be met.

[8] If external event considerations are added at later stages, they may lead to costly major modifications or even unacceptable safety levels.

[9] A consensus needs to be found on whether human actions of malevolent character should be explicitly addressed in plant design [3].

(V) Considerations relevant to the vendor/ vendor and regulator (continued 1)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	V.3. Plant Efficiency and Competitiveness	
V.3.1	The flexibility of an offered plant in power range, siting, fuel cycle options, and applications with a option to tailor it rapidly to the demands of an individual customer	SMR/ [1, 3, 4]
V.3.2	The reactor and safety systems jointly optimized in order to ensure a cost effective safety design	AR - SMR/ [1, 3]
V.3.3	Higher conversion efficiency and purposeful use of the reject heat	SMR/ [3, 4]
V.3.4	Increased options for local participation in plant construction, e.g., achieved by assigning limited or no safety function to the balance of plant	SMR/ [4]
V.3.5	Option of local manufacturing of the reactor and nuclear steam supply components secured by simplicity of the design and components, matching the capabilities of a local industry	SMR/ [5]
	V.4. Qualification and Licensing[10]	
V.4.1	Simplified licensing procedures, e.g., eliminated off-site emergency planning and/or simplified licensing of a replicate plant construction	SMR/ [1, 3, 4]
V.4.2	Innovative design features supported and encouraged by a rational technical and non-prescriptive basis to define a severe accident[11]	SMR/ [2]
V.4.3	Regulatory rules and procedures incorporating a technology-neutral approach, which supports the full potential of the innovative SMRs for competitiveness through a simplification of their design and the abandoning of some costly safety systems	SMR/ [1, 4]
V.4.4	An integrated risk-informed approach established in the design and licensing for the consideration of external events together with internals events, yielding cost effective solutions that meet quantitative probabilistic safety considerations for the plant, as well as deterministic success considerations for the systems, structures and components important to safety[12].	AR/ [2]
V.4.5	A consensus regulatory approach to validate and qualify the reliability of passive safety systems developed and emplaced to enable risk-informed qualification and licensing (such approach addresses both internal and external events and combinations thereof).[13]	AR/ [3, 6]
V.4.6	Joint evaluation of new designs by regulatory agencies (e.g., the Multi-National Design Evaluation Programme (MDEP)	AR/ [1, 3]

[10] The considerations of section V.5 could be rated as relevant to both vendors and regulators.

[11] Core melt need not be postulated to occur; the rational technical basis could be derived from realistic scenarios applicable to the specific plant design.

[12] Rules for combination of events and combination of loads could come out of this approach, need to be developed

[13] For example, performance of natural circulation based systems (low driving head), fluid devices, passive valves etc. needs to be assessed under strong ground motion conditions, fire, etc.

(V) Considerations relevant to the vendor/ vendor and regulator (continued 2)

#	Consideration/ Subject Area of Relevance	Application range/ Reference
	V.4. Qualification and Licensing (continued)	
V.4.7	Regulators have been involved from early design stages to ensure that rules and procedures matching an innovative safety design are ready on time	AR/ [1]
V.4.8	Rules and practice of "License by test" established[14]	SRWOR/ [1, 4]
	V.5. Economy of Production and Financial Risk	
V.5.1.	The economy of multiple small modules and the associated risk reduction, achieved through design standardization, factory mass production, equipment unification, common basis for design certification, and construction in series[15]	SMR/ [1,3, 4]
V.5.2	Proveness of the basic NPP technologies[16]	AR/ [3]
V.5.3	Provision of flexibility in design, siting and applications	SMR/ [1, 4]
V.5.4	High conversion ratio achieved to improve the potential for fuel load leasing and distribute risks by selling the fuel load to a third party who could then lease it to the customer (internal breeding ratio of unity maintains fissile mass "principal" for the load owner)	SRWOR/ [4]

[14] A reactor prototype could be built and subjected to a pre-agreed set of anticipated transient without scram (ATWS) and other accident initiators. By demonstrating safety based on passive response, on the prototype, the licensing authority might be able to certify the design, permitting the manufacture of many tens (or hundreds) of replicate plants to the set of prints and design specifications used for the prototype. In order to assure that aging effects do not degrade the passive safety features of deployed plants, the licensing authority could prescribe the performance of periodic in-situ tests on the plant to confirm continued presence of reactivity feedbacks in the required range and of passive decay heat removal continuously operating at the required rate.

[15] The vendor, who has a start-up risk of building a factory for mass production and creating a logistics and installation capability, could spread his cost of risk over many plants.

[16] The requirement of technology proveness does not mean that design configuration of a plant cannot be innovative; there are examples when users accept FOAK plants in their countries on condition that they are licensed in a vendor country; moreover, it is generically anticipated that the vendor could offer a partnership and attractive conditions to the user who would agree to buy an innovative FOAK plant.

($) Considerations relevant to the investor[17]

#	Consideration/ Subject Area of Relevance	Application range/ Reference
$.1	Lower upfront investments with a shorter time before the start up of a revenue stream, i.e., lower Capital-at-Risk	SMR/ [3, 4]
$.2	Incremental capacity increase through modular approach with a staggered build of reactor modules or with sequential clustering of several NPPs at a single site to match the energy demand growth in a timely manner and minimize Capital-at-Risk	SMR/ [1, 3, 4]
$.3	Proveness of the basic NPP technologies[18]	AR/ [3]
$.4	The flexibility of an offered plant in power range, siting, fuel cycle options, and applications with a option to tailor it rapidly to the demands of many individual customers	SMR/ [1, 3, 4]
$.5	Reduced off-site emergency planning requirements, resulting in an enhanced economic viability and improved public acceptance	SMR/ [1, 3, 4]
$.6	Minimum reliance on complex local infrastructure, to minimize infrastructure emplacement requirements and associated costs	SMR/ [1, 4]
$.7	The economy of multiple small modules and the associated risk reduction, achieved through design standardization, equipment unification, factory mass production, common basis for design certification, and construction in series[19]	SMR/ [1, 3, 4]
$.8	An option to spread overall financial risk between several stakeholders, e.g., by relying on multiple reactor module (nuclear steam supply system) supply or leasing with the balance of plant being build by the user at his own cost, or on the economy of scale centralized fuel cycle service centres operated by international consortia, or on leasing of a whole-core fuel load a priori sold to the third party, etc.	SMR - SRWOR/ [3, 4]

[17] In some cases the investment can be made directly by the user; however, in view of a relatively high overnight capital cost of nuclear power plants, there is a global tendency to attract investors other that the user, e.g., by establishing public-private partnerships in a country or by relying on credits from national or international financial institutions, etc.

[18] The requirement of technology proveness does not mean that design configuration of a plant cannot be innovative; there are examples when users accept FOAK plants in their countries on condition that they are licensed in a vendor country; moreover, it is generically anticipated that the vendor could offer a partnership and attractive conditions to the user who would agree to buy an innovative FOAK plant.

[19] The vendor, who has a start-up risk of building a factory for mass production and creating a logistics and installation capability, could spread his cost of risk over many plants.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Innovative Small and Medium Sized Reactors: Design Features, Safety Approaches and R&D Trends, Final report of a technical meeting held in Vienna, 7-11 June 2004, IAEA-TECDOC-1451, Vienna (2005).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Advanced Nuclear Plant Design Options to Cope with External Events, IAEA-TECDOC-1487, Vienna (February 2006)

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Status of Innovative Small and Medium Sized Reactor Designs 2005: Reactors with Conventional Refuelling Schemes, IAEA-TECDOC-1485, Vienna (March 2006)

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Status of Small Reactor Designs without On-site Refuelling, IAEA-TECDOC-1536, Vienna (March 2007)

[5] Meeting report of IAEA technical meeting "Review of Enabling Technologies for SMRs" held in Vienna, Austria, on 16-20 October 2006 (available upon request from: v.v.kuznetsov@iaea.org)

[6] Meeting report of IAEA technical meeting "Status of Validation and Testing of Passive Safety Systems for SMRs" held in Vienna, Austria, on 12-16 June 2006 (available upon request from: v.v.kuznetsov@iaea.org)

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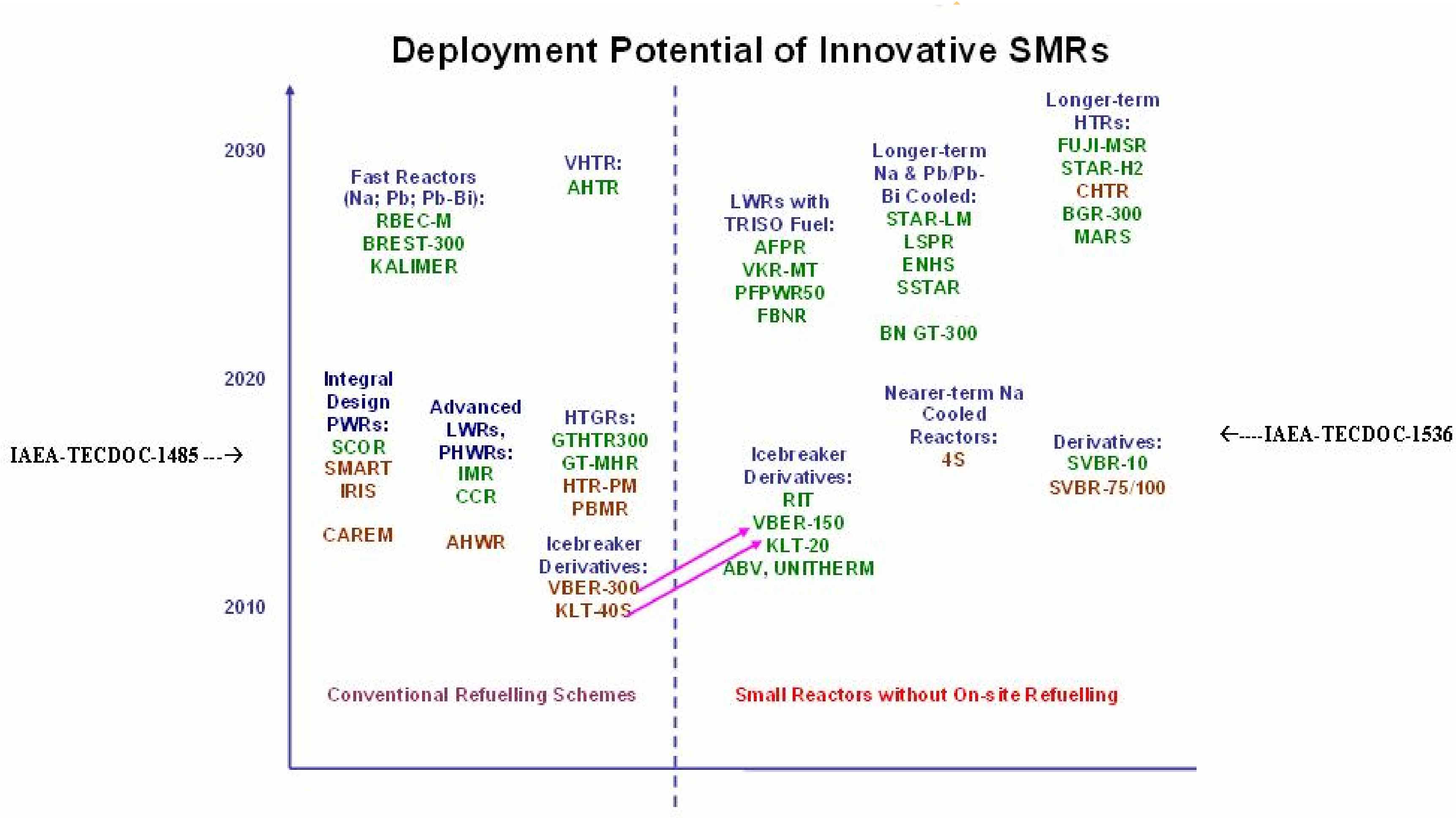

Brown colour indicates concepts that show progress towards advanced design stages, licensing, or deployment