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Elements of SMR licensing roadmap for Finland

Prof. Juhani Hyvärinen
Lappeenranta-Lahti University of Technology
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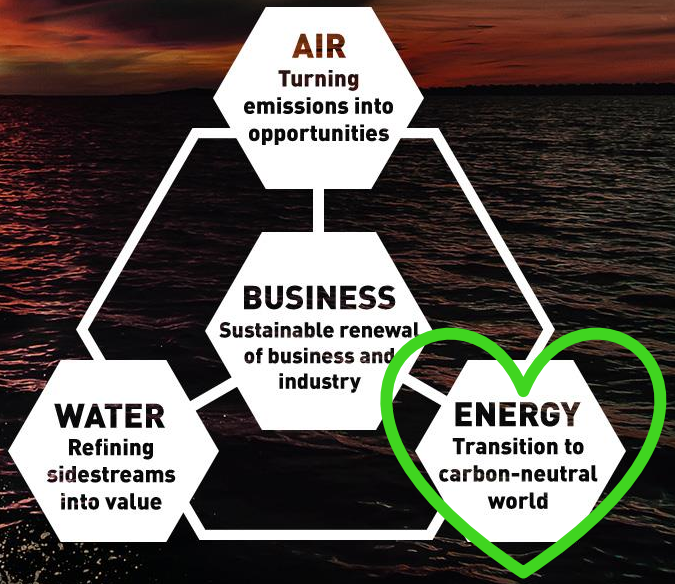
SYSTEM

EARTH



Outline

1. Small Modular Reactors – an overview
   - Sizes, uses, technologies
2. New actors in nuclear business
3. Licensing approaches and factors
4. Conclusions

“SMR” is a very broad notion

Usually, “SMR” < 1000 MWth, ~300 MWe

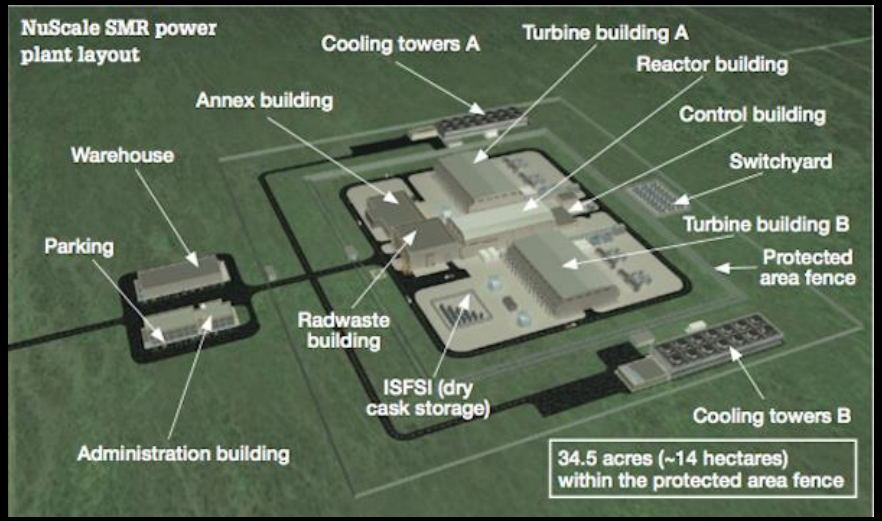
Near-term deployable technology: **Light Water**

Other technologies demoed (gas-cooled) or promoted (liquid metal cooled, molten salts)

Use →	Electricity	Co-generation	Naval	District heat / Desalination
Thermal power (MW)	1000..10	1000..100	200..100	100..10
Units / installation	1..12	1..12	1..2	2..4
Nature of application	Traditional	Heat new	Movement	New

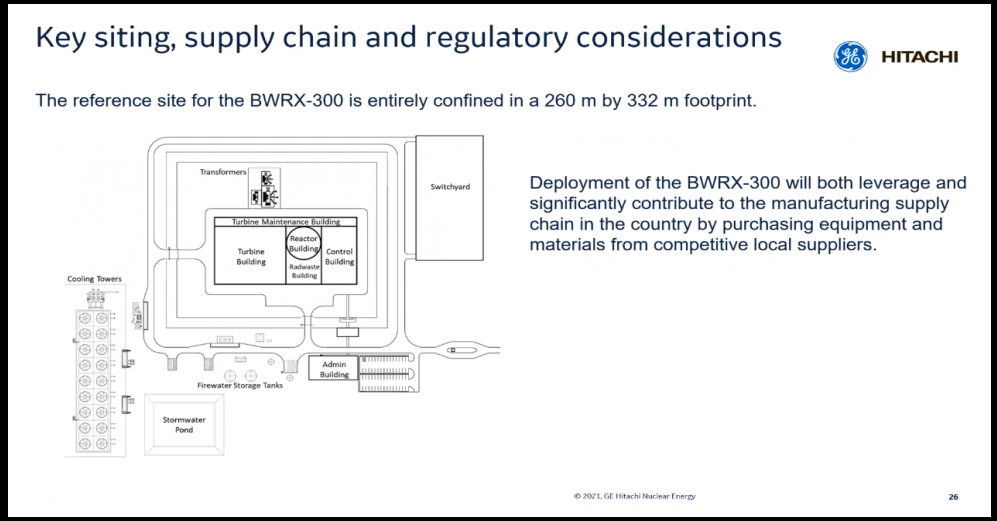
Two well known options

NuScale



[Modern Power Systems, Oct 2016]

BWRX-300



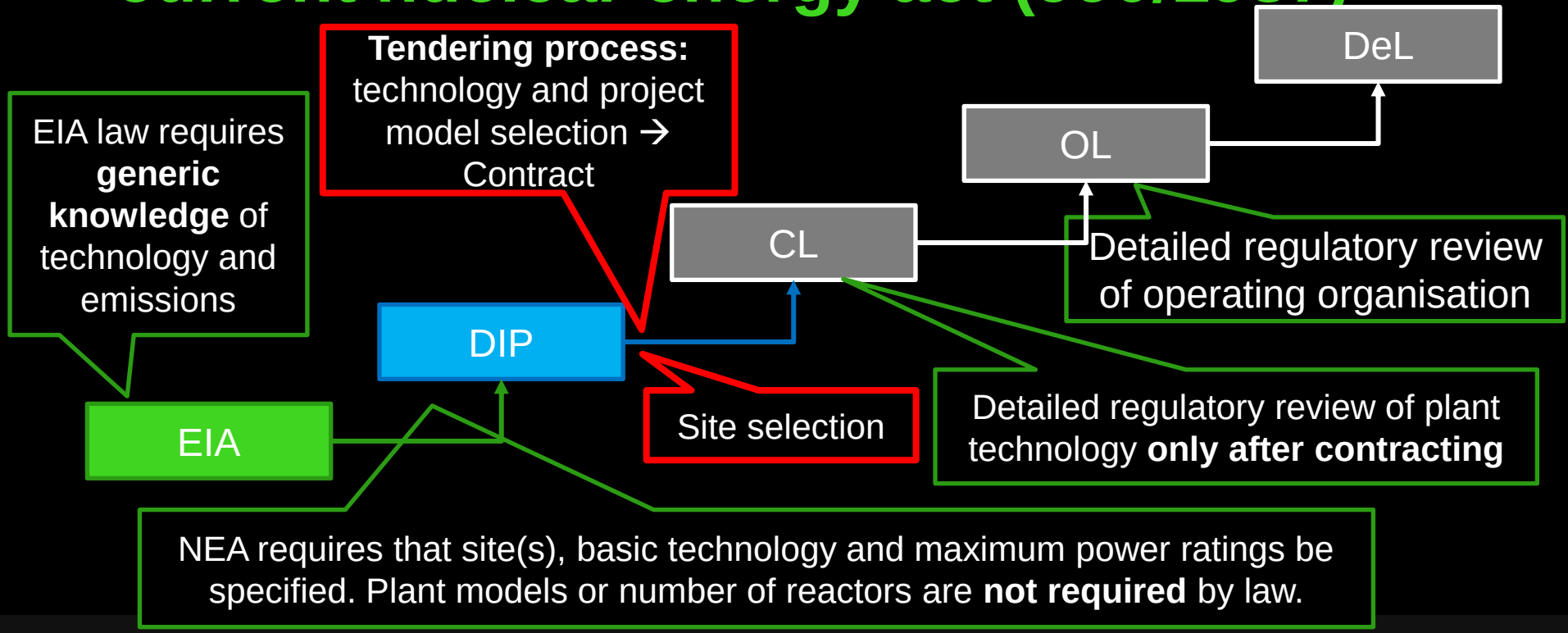
[GEH presentation for EcoSMR, Nov 2021]

Commercial options

Largish LWR-SMRs: NuScale and BWRX-300

- From the outside, these look much like large plants
- US designs, follow current US rules, i.e. large reactor General Design Criteria (10CFR50 App. A) and regulatory practices
- Safety feature failure criterion N+1, no online preventive maintenance foreseen. There is not much to maintain online…
- Two licensing paths are feasible in the US: 10CFR50 CL,OL and 10CFR52 ESP/DC,COL

An SMR project is totally feasible current nuclear energy act (990/1987)



Nuclear legislation evolution has begun

MEAE working group on Nuclear Energy Act report released in Aug 27, 2020 **foresees many new uses**

[Ydinlaitosten elinkaaren sääntelyn kehittäminen, Työ- ja elinkeinoministeriön julkaisuja 2020:43, http://urn.fi/URN:ISBN:978-952-327-537-9]

MEAE has announced in Dec 2021 that revision of legislation has begun

Ydinreaktorien	Nykyisiä toimintoja ja toimintamalleja	Uusia toimintoja ja toimintamalleja			Nykyisiä toimintoja ja toimintamalleja
Tehotaso	Isot voimalaitokset > 1 000 MWth	Pienet modulaarisset reaktorit (SMR) < 1 000 MWth	Pienet lämmitysreaktorit < 300 MWth	Laivareaktorit 100–200 MWth	Tutkimusreaktori < 20 MWth
Ensisijainen käyttötarkoitus	Sähköntuotanto	**Sähköntuotanto** tai yhdistetty sähkön ja lämmön tuotanto	Lämmöntuotanto: kaukolämpö, talvimerenkulku	Merenkulku	Tutkimustoiminta, isotooppituotanto
Sijoittelu Suomeen	Vanha tai uusi voimalaitospaikka, harvaan asuttu seutu	~10 uutta laitospaikkaa: isot kaupungit, tehdaspaikkakunnat	10–50 uutta laitospaikkaa: pienemmät kaupungit, isot vesiliikenneväylät	Satamat (usein mutta lyhytaikaisesti), Telakat (harvoin mutta pitempään)	Ydinenergia-alan tutkimuskeskittymä
Omistaja	Suomalaiset Mankala-yhtiöt, valtionyhtiö	Alueelliset tai kunnalliset energiayhtiöt; (valtionyhtiö?)	Alueelliset tai kunnalliset energiayhtiöt	Varustamo	Yliopisto
Toteutustapa	Omistaja ostaa täysin ulkomaista teknologiaa Alihankintaa Suomesta	Omistaja ostaa täysin ulkomaista teknologiaa Alihankintaa Suomesta	Omistaja ostaa kotimaista teknologiaa (24–120 MWth) Toteutus pääosin kotimaisin voimin	Telakka hankkii koeteltua teknologiaa ulkomailta	Omistaja kehittää kotimaista teknologiaa
Käyttäjä	Omistaja	**Omistaja** tai palveluna ostettu käyttö	Omistaja tai palveluna ostettu käyttö	Varustamo, voi ostaa palvelua teknologiatoimittajalta	Omistaja
Jätehuolto	Voimalaitokset itse tai yhteistyössä	Ensisijaisesti ydinenergian käyttäjien yhteistyö kotimaassa,	Ensisijaisesti kaikkien ydinenergian käyttäjien yhteistyö kotimaassa,	Ensisijaisesti kaikkien ydinenergian käyttäjien yhteistyö kotimaassa,	Ensisijaisesti kaikkien ydinenergian käyttäjien yhteistyö kotimaassa

New licensing process elements would benefit SMRs (too)

Technology and site approvals **independent of individual projects**

Technology approval
- Regulatory review and approval of design
- **Plant vendor** interfaces with STUK
- Includes enveloping site conditions as design input

EIA
- Max thermal power
- Emissions limits (thermal, chemical, activity)
- All sites
- Acknowledges basic technologies

DIP
- **Political decision**
- Overall good of the society
- Candidate municipalities' approval
- Power limits
- Basic technology + STUK position on generic acceptability
- **No technical review**

Construction License
- Approval of plant design
  - Technology
  - Site
- Compatibility of design and site

…

Site review (regulatory approval)
- Technical study to establish applicable site conditions, incl. emergency zoning
- **Site owner** interfaces with STUK

[From MEAE New technologies WG, 2016]

Regulatory **controls during construction** need to be streamlined as well

New players in nuclear business?

Established **nuclear company**, turnover > 1 B€/a
Imports **commercial SMR**
Produces **electricity** on an established nuclear site

New players in nuclear business?

Established **nuclear company**, turnover > 1 B€/a	
	Established **large company**, turnover > 1 B€/a
Imports **commercial SMR**	Imports **commercial SMR**
Produces **electricity** on an established nuclear site	
	Produces **electricity and/or heat** on a new nuclear site, close to population

New players in nuclear business?

Established **nuclear company**, turnover > 1 B€/a		
	Established **large company**, turnover > 1 B€/a	Established **mid-size company**, turnover ~0.1 B€/a
Imports **commercial SMR**	Imports **commercial SMR**	
		Builds **domestic small reactors**
Produces **electricity** on an established nuclear site		
	Produces **electricity and/or heat** on a new nuclear site, close to population	Produces **heat** on an own new nuclear site, close to population, or Becomes partial owner of a **joint cogeneration** facility, with a large industrial partner

New working models for development, build, operation, decommissioning

Current regulations presume a “license holder” who alone is responsible of safety

Underlying assumptions include that

- Plants are owned by large (national) energy companies that have broad in-house competence
- Industrial base is able to provide dedicated contracted services (e.g. specialty manufacture) at reasonable cost

New build experience seems to have invalidated both of these beliefs.

New model is needed to assign responsibility to the capable parties.

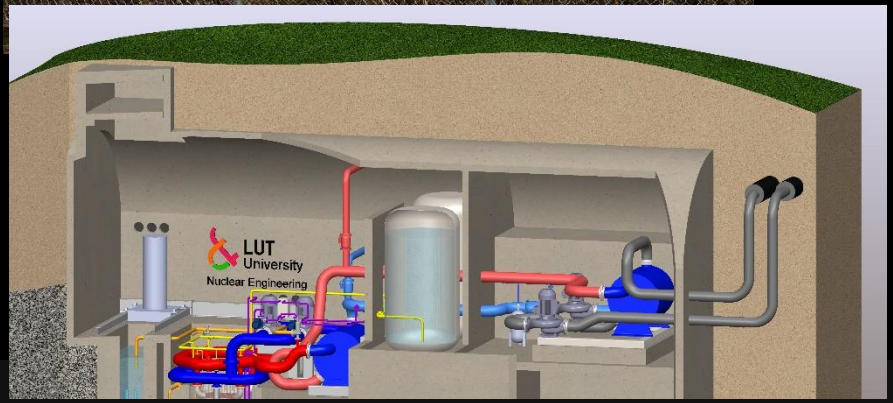
	Old license holders	New “license” holders
Technology	Plant owner • Outsources to Vendor	**Vendor/IPR holder**, via Design Certification
Site	Plant owner	**Site owner** – can be Owner of Plant owner, or transfer site to Plant owner (later)
Operations	Plant owner	Plant owner • May outsource to a **Service provider**
Liability	Plant owner	**Plant owner**
Waste management	Plant owner (financial) • may outsource to daughter company	**Plant owner (financial)** • May outsource to a **Service provider**

Security design for very small SMRs

Commercial SMR plant security provisions are similar to large reactors: double fence, on-site security organisation, distance to other facilities

Very small SMRs, especially district heating reactors, could get by with simpler provisions:

- Underground siting
  - No external features of safety significance
  - No vulnerable connections (pipes, cables, ducting all underground)
- Controlled access
  - Plant fence at a radius of ~50 metres, mainly to indicate where digging or drilling is forbidden, to protect underground ducting
- Information security
  - Remote operation, if used, using dedicated secure data links



Nuclear responsibilities

- Licensee's technology competence – level is subject to current debate
- International obligations, NOT negotiatable
  - Nuclear **material safeguards** – nonproliferation is important, and must be taken care of
  - Nuclear **liability insurance**. According to the Paris convention, liability can be adjusted from 700 M€ down to 70 M€, based on plant characteristics and accident consequences [SopS 112–114/2021 §7 a) i)]

(Paris Convention on Third Party Liability in the Field of Nuclear Energy, 1960, as amended by Additional Protocol in 1964, Protocol in 1982 and Protocol in 2004, https://www.oecd-nea.org/jcms/pl_20196/paris-convention-on-third-party-liability-in-the-field-of-nuclear-energy-paris-convention-or-pc)

Conventional permitting also applies

State-level decision making is not enough!

- Land use planning – local political approval necessary
- Construction permit by local authorities
- Grid compatibility – Fingrid for national transmission of electricity
- Environmental permits by environmental authorities

Current SMR licensing roadmapping

MEAE VN-TEAS
PIEMOS: Siting, Nuclear materials, Modular technologies (LUT)

STUK
Strategy renewal, STUK Requirement and YVL Guide renewal (in-house)

Finnish Energy Technology Association (ET ry)
Proposal for SMR licensing model and regulations (Platom)
Position paper on SMR licensing (ET)
Review of land use planning and licensing (Afry)

Business Finland
EcoSMR, WP1: Licensing, siting, safety analyses (VTT, LUT)

Conclusions

- Commercial (large) SMR technology becoming available
- Applications: electricity, heat or both; civil marine?
- New players may emerge on the field
- Nuclear licensing processes already being improved
  - Individual nuclear projects could go ahead right away
  - Many adaptations to various legislations would be needed for full benefits of small modular nuclear
  - Many projects to provide input to legislation and regulation revision
- Conventional licensing also applies
- Much potential to do good: broaden business, help climate, revitalize nuclear industry practices, *focus on the essentials*

Thank you!

juhani.hyvarinen@lut.fi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