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AVAILABLE NUCLEAR TECHNOLOGY FOR NEWCOMERS AND ITS LONG TERM PERSPECTIVES

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NEWCOMERS

- What is the ideal Nuclear Power Plant for a “newcomer” from a developing country?
- Does the present technical market have a Nuclear Power Plant for developing countries?
- What technology will developing countries have available in 10-15 years from now?

This paper will only deal with the Nuclear Power Plant itself, not with financial, political, or proliferation aspects.



The goal → electricity

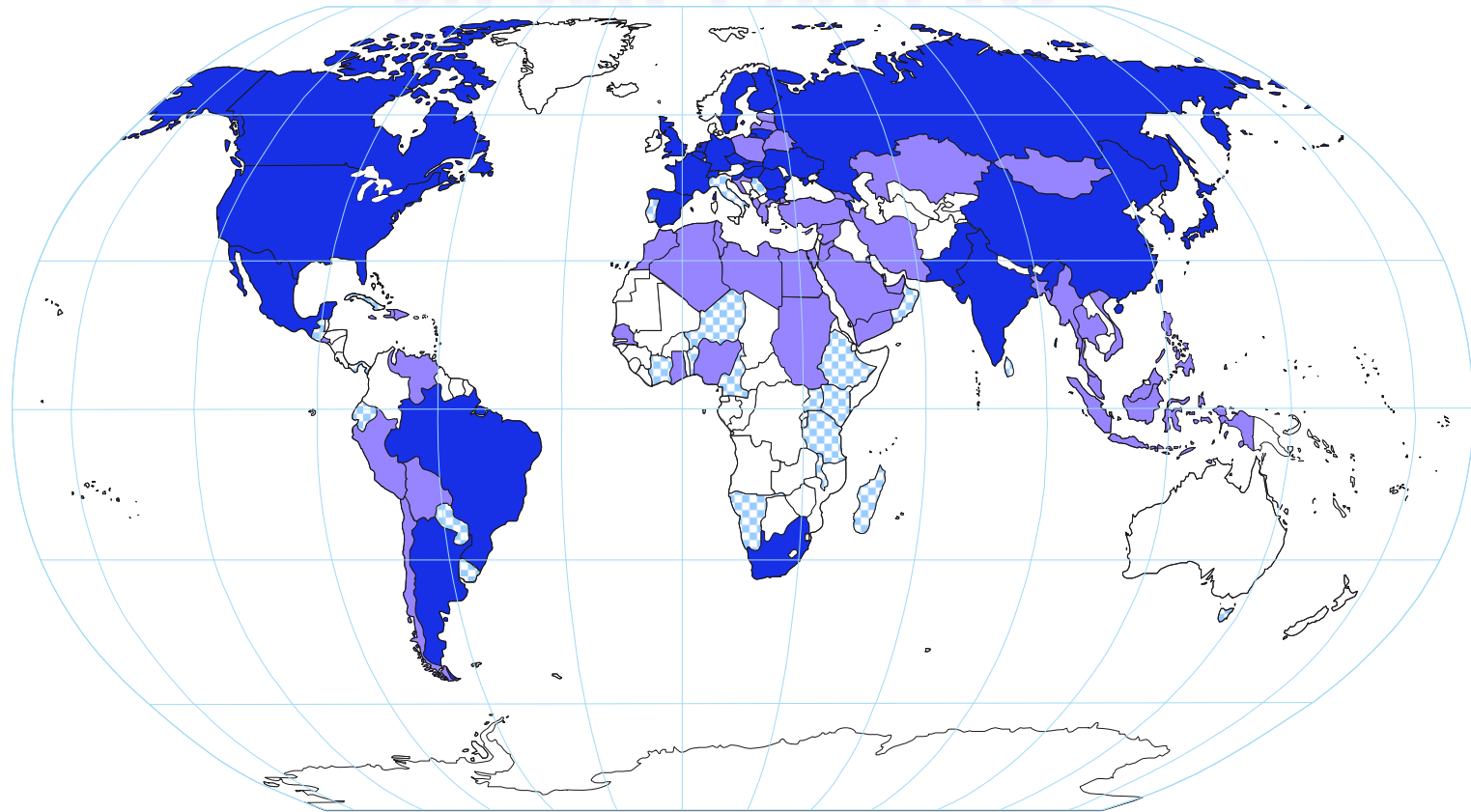
Present situation

- ❑ 30 countries currently using nuclear power for electricity generation
 - ❑ 24 intend to build new plants (power > 1000 MW_e)
- ❑ 43 countries have expressed interest in building their first Nuclear Power Plant
- ❑ 25 countries are actively considering nuclear power programs to meet their energy needs → the so called **“NEWCOMERS”**

Source: IAEA



NEWCOMERS



■ Operating (30) ■ Considering (43) ■ Countries having expressed interest (25)

Source: IAEA (April'09)

Total: 68 countries

MAINLY FROM DEVELOPING COUNTRIES

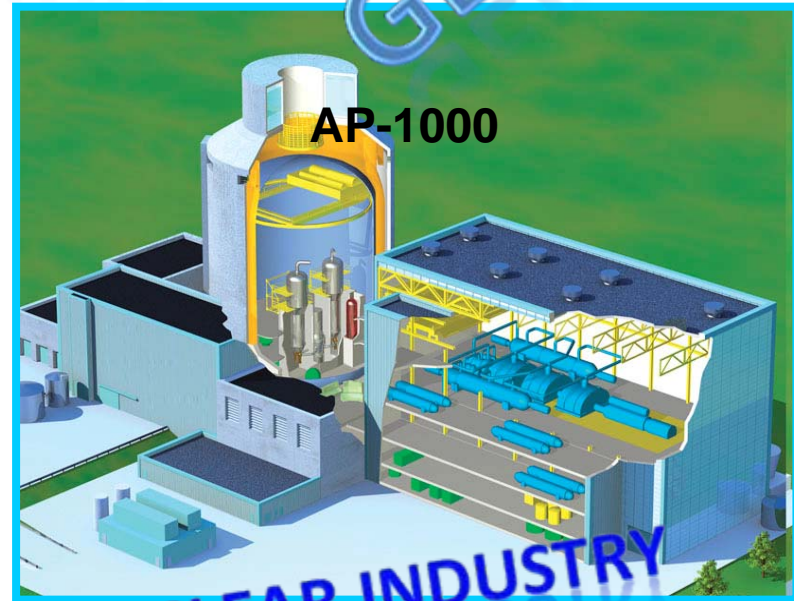


PRESENT SUPPLIERS LARGE NPP

GEN III+

A recent study carried out by Nuclear Power Corp of India shows → today, only four reactor manufacturers as front runners:

1. Westinghouse - AP1000
2. GE/Hitachi - ABWR
3. AREVA – EPR
4. ROSATOM - VVER



INTERNATIONALIZATION OF THE NUCLEAR INDUSTRY

Nuclear suppliers have decreased over the past 20 years. There are fewer reactor designers and less reactor choices.



PRESENT NUCLEAR POWER SCENARIO

- ❑ Most industrialized, developed countries, have at present Nuclear Power Plants in operation.
- ❑ Most potential “newcomers” are developing, non-industrialized countries; as Jordan, Uruguay, Chile, Egypt, etc.
- ❑ Commercially available Nuclear Power Plants, have an electric power output higher than 1.000 MW_e

Not 'one-size-fits-all'



Flamaville (France) EPR 1600 MW_e



WHAT ARE DEVELOPING COUNTRIES LOOKING FOR?

- Power ranging anywhere from 300 to 600 MW_e (should not exceed 5-10% of the grid capacity).
- Simple and proven technology.
- Significant participation of the local industry during construction.
- Small number of qualified manpower for operation and maintenance.
- Assured local technology and supply for operation and maintenance.



ATUCHA 1 – NPP Argentina

- Electrical Power: 351 MW_e
- In operation since 1974
- The local participation during its construction was:
 - Civil Works: 90%
 - Erection of components: 50%
 - Electromechanical supplies: 13%
- Cumulative Availability Factor: 72%
- Cumulative Load Factor: 70%
- Operation and Maintenance carried out by Argentina.

Nuclear manufacturers should aim for proven reactor designs, with an electrical power output appropriate to countries requirements: **Not 'one-size-fits-all'**

SMALL & MEDIUM POWER REACTORS

Reactors up to 700 MW_e are currently considered as Small and Medium Reactors (SMR).

The ranges are:

- | | |
|--|-------------------------|
| <input type="checkbox"/> Small reactors | < 300 MW _e |
| <input type="checkbox"/> Medium reactors | 300-700 MW _e |
| <input type="checkbox"/> Large reactors | >700 MW _e |

- Present potential market: newcomers developing countries (Their capacity of transmission grids is not large enough to accommodate LRs).
- Economically → large reactors – but, their huge capital investment reduces their advantages → SMRs appear more attractive.
- Further technological breakthroughs will be necessary, if SMRs are to compete with LRs.

Present builders of MRs

1. Atomic Energy of Canada – CANDU6
2. China National Nuclear Corporation - PWR
3. Nuclear Power Corporation of India Limited – PHWR



CNE
CANDU6
Argentina

ENHANCED CANDU-6 AECL

CHINA - Two CANDU-6 were built:

- ❑ in time frames in the order of five years, and
- ❑ miraculously for the nuclear industry, on budget.

Note: There will be markets for the EC-6 in developing countries that have reserves of uranium and want to be independent of foreign enrichment.



Qinshan Nuclear Power Phase III Project (China)

but ...of the commercial reactors in operation today, approximately 82% are H₂O reactors and only 10% are D₂O reactors (6,3% of total electrical power total).



CHINA PWR

Designed, constructed, operated and managed by China on it's own



Unit	Type	Status	Net MW	Gross MW	First Output
QINSHAN 1	PWR	Operational	288	310	15 DEC 1991
QINSHAN 2-1	PWR	Operational	610	650	06 FEB 2002
QINSHAN 2-2	PWR	Operational	610	650	11 MAR 2004

Too busy with its domestic Nuclear Program to be a Nuclear Supplier (not an “active player” in the international market)



INDIA

The new series of 490 MW_e net, nuclear reactors, are developed indigenously from the 220 MW_e PHWR model



Kaiga

Location: Karnataka

Operator: Nuclear Power Corp of India Ltd

Configuration: 3 X 220 MW PHWR



Kakrapar

Location: Gujarat

Operator: Nuclear Power Corp of India Ltd

Configuration: 2 X 220 MW PHWR

Too busy with its domestic Nuclear Program to be a Nuclear Supplier (not an “active player” in the international market)

India has as its goal: “to become a world leader in fast reactors and thorium fuel cycle nuclear technologies”

Available SMRs

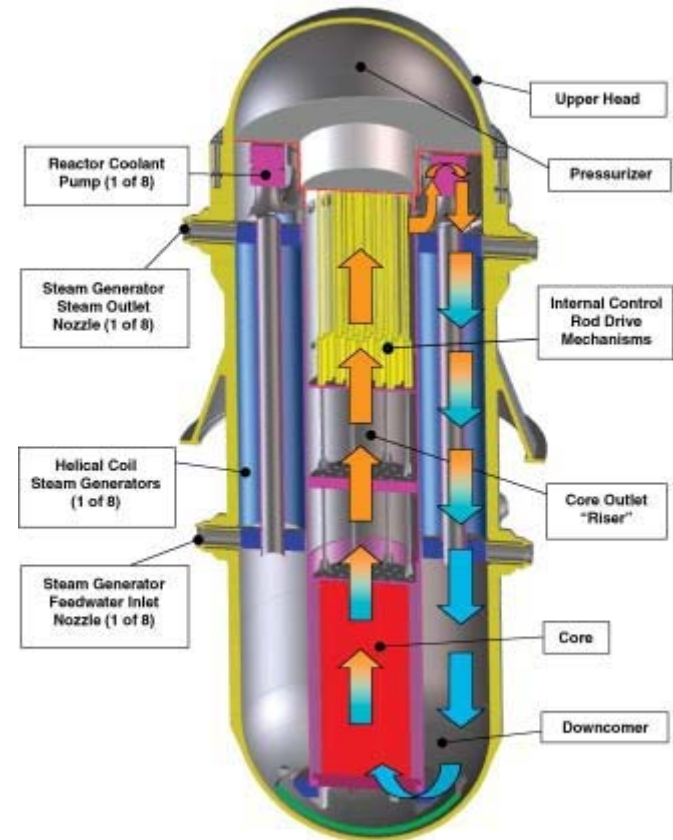
Presently available SMRs:

- ✓ IMR
- ✓ IRIS
- ✓ SMART
- ✓ PBMR*
- ✓ KLT
- ✓ CAREM

Conceptual development

Prototypes under construction

* High Tech



About 60 concepts and designs of innovative SMRs are analyzed or developed within national or international programs (Source: IAEA)



KLT-40S REACTOR



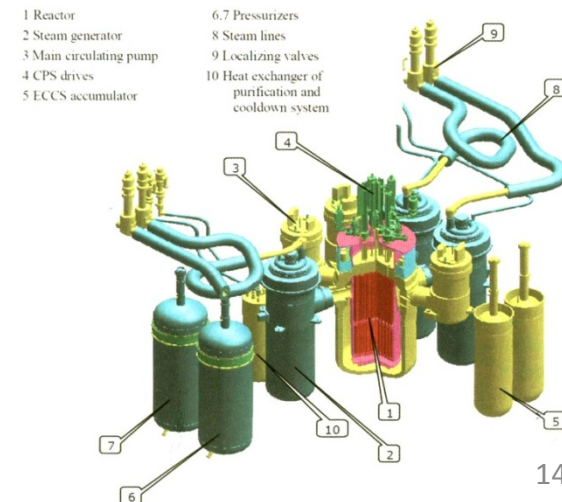
- Started construction: April 2007
- Start of operation: planned for 2010
- Output:
 - 70 MW_e
 - 300 MW_{th} heat power or
 - 240.000 m³ of water
- Plant type: PWR-FNPS (Floating Nuclear Powered Stations)
- Constructed at Sevmash Arctic military shipyard
- Location: To be stationed in remote locations around Russia
- Reactor: Modified KLT-40S
- Fuel: Low-enriched fuel (U-Silicides up to 20%)



Floating power-generating unit with a KLT-40S reactor system for electricity and water desalination

Key Players:

Plant owner/operator: Rosatom
 Reactor manufacturer: OKBM

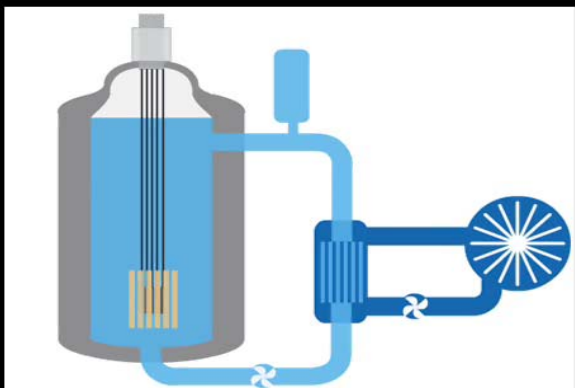
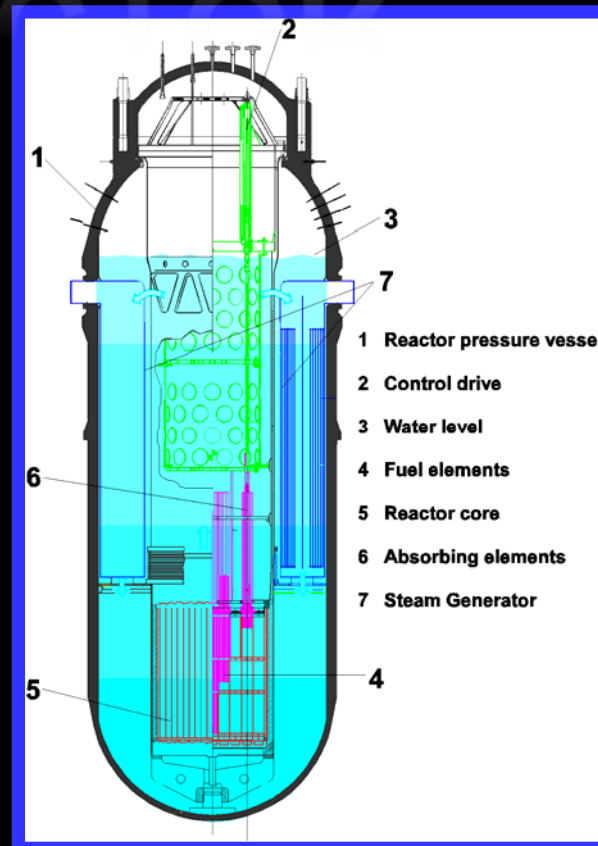




CAREM REACTOR



- ❑ Type: integrated PWR
- ❑ Designer: CNEA
- ❑ Power: 25 to 300 MW_e
- ❑ CAREM25 Prototype under construction
- ❑ Owner/Operator: CNEA
- ❑ Start of operation: planned 2014
- ❑ Integral SG
- ❑ Enrichment 1,8-3,1%
- ❑ H₂O Cooling: Natural Circulation



CAREM is an innovative, simple and Small Nuclear Power Plant

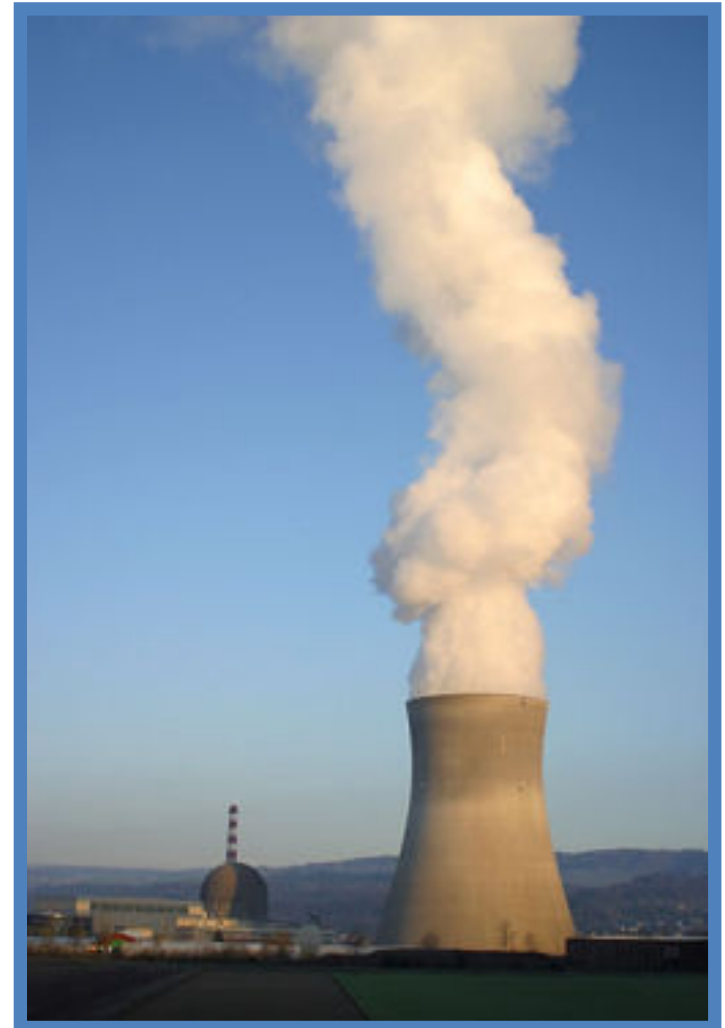
SRs as the “bridge project”

FIRST NUCLEAR ERA

Industrialized Countries

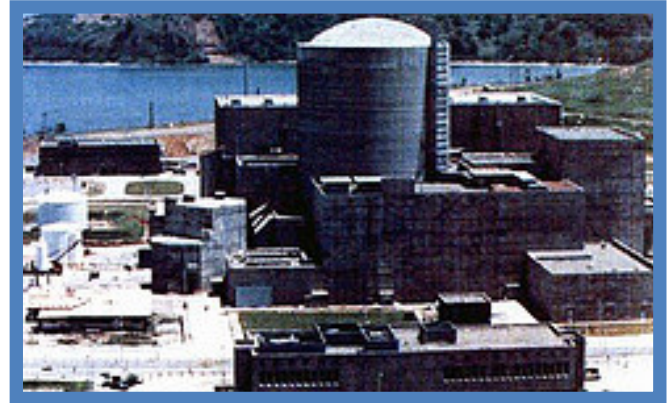
“Steps to Nuclear Power”:

- 1. Installation of a nuclear research center, (frequently around a research reactor facility)**
- 2. Design and Construction of a Demonstration Nuclear Power Plant**
- 3. Finally → construction of a commercial NPP (in some cases under a turn-key contract).**



Developing countries

1. Applications of radiation in industry and in medicine.
2. The second step → installation of a nuclear research center (frequently around a research reactor facility).
3. Finally → commercial NPP (on a turnkey basis).



Mothballed Philippine Nuclear Power Plant

**No Demonstration
Nuclear Power Plant**

**In most cases →
failed or delayed**

REASONS FOR THE DELAY

- Economical effort.
- Industrial infrastructure.
- Human resources.
- Licensing.
- General Cultural Attitude.
- Lack of a long term commitment.



Angra 1 – start construction 1971 - operation (626 MW_e)
Angra 2 – start construction 1977 – operation 2000 (1229 MW_e)
Angra 3 - most components purchased in 1995 but has been in storage ever since, consuming 50 million dollars a year in maintenance costs.

BRIDGE PROJECT

Small Power Reactors could be used as a Bridge Project:

- **Power 25 to 100 MW_e → modest resources in all aspects:**
 - **financial** (smaller financial risk than for a large plant)
 - **local technology,**
 - **manpower requirements and**
 - **local industrial infrastructure.**

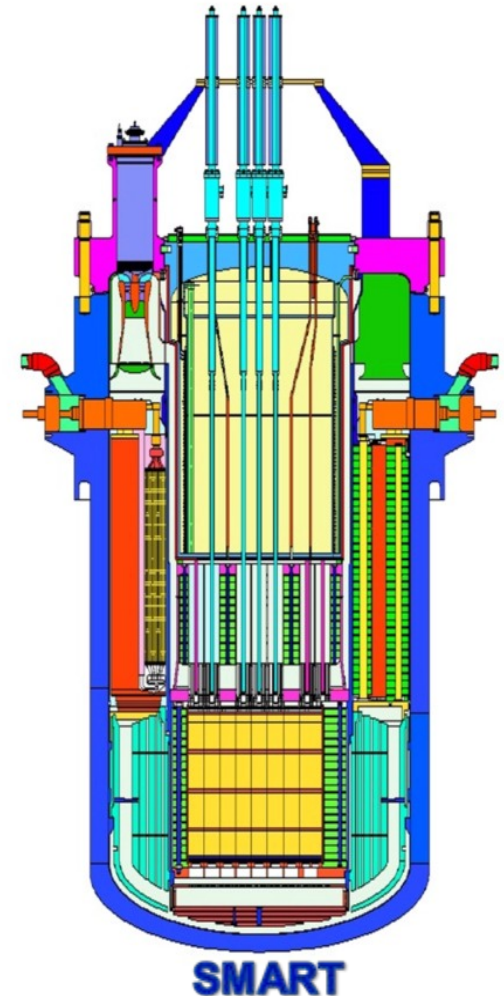
- **Technologically more complex than a Research Reactor but significantly less complex than a full-size NPP.**

- **Safety based on simple principles → minimum degree of complexity for:**
 - **licensing,**
 - **operation and**
 - **maintenance.**

- **The reactor produces saleable services: usable heat, steam, and especially electric energy.**

but.....

- ❑ The time frame for the availability of commercial SMRs is very important → most developing countries could not wait for another two or three decades to increase their installed electricity generation capacities.
- ❑ A new SMR design must be first demonstrated in the country of origin, before another country will buy one. No developing country would want to be “a guinea-pig” for a new design.



Even if Generation IV is available in 15 years from now, it will hardly be the solution for “newcomers”

Today

Only NPP > 1000 MW_e are available
Market focus → industrialized countries



MEDIUM TERM

10 TO 15 YEARS FROM NOW

- SMR prototypes in construction:
 - KLT- 40S
 - CAREM25 (prototype of CAREM300 - 300 MW_e)
- other SMRs projects (IRIS, SMART, etc.).



CAREM RPV

CONCLUSIONS

- ✓ one-size Power Plant does not fit all requirements
- ✓ presently available NPPs > 1.000 MW_e
- ✓ best project for “newcomers” → SRs → “bridge project”
- ✓ SMRs are also the preferred option for non-electrical application of nuclear power:
 - ❑ Desalination of seawater
 - ❑ District heating
- ✓ at present → no “active player” for LW SMRs

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Nuclear Energy in the 21st Century

Addressing Energy Needs and Environmental Challenges

Organized by the



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