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SMALL MODULAR REACTORS

CLEAN AND AFFORDABLE ENERGY, SWOT ANALYSIS

Atif Mahmood Tayyab
Principle Scientist
Pakistan Atomic Energy Commission

LAYOUT

- Climate Change
- Energy Mix of Pakistan Power Sector
- Nuclear Power Plants
- Power Sector Challenges & Future Outlook
- Small Modular Reactors
- SMR SWOT Analysis
- SMR-Specific Features
- Sustainable Development Goals
- Powering The Future

CLIMATE CHANGE

Temperature Rise

- Historical temperature trends over the past century.
- Accelerated warming since the mid-20th century.
- Implications for extreme weather events.

Extreme Weather Events

- Increase in frequency and intensity of hurricanes, droughts, floods, and wildfires.
- Economic and humanitarian consequences.

Melting Ice and Rising Sea Levels

- Decline of polar ice caps and glaciers.
- Sea level rise and coastal erosion.
- Threats to low-lying areas and island nations.

Biodiversity Loss

- Habitat destruction and altered ecosystems.
- Species extinction and disruption of food chains.

Ocean Acidification

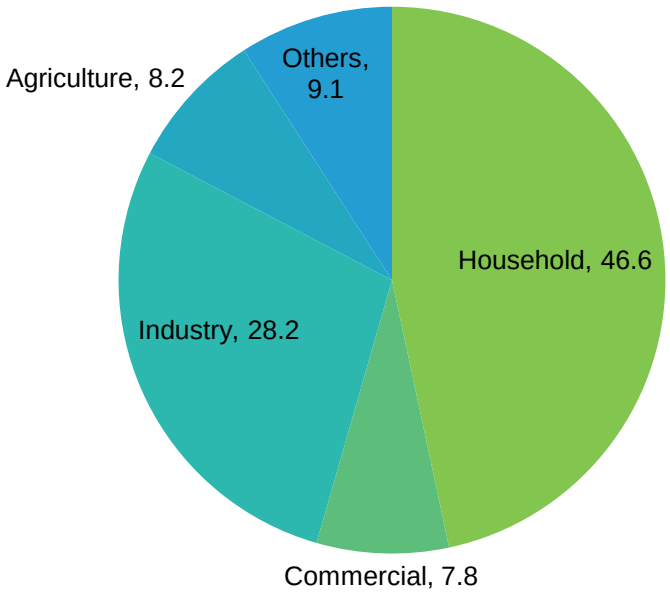
- Increasing CO_2 absorption by oceans.
- Impact on marine life and coral reefs.
- Consequences for fisheries and biodiversity.

Human Health Impacts

- Spread of diseases due to changing climate conditions.
- Heat-related illnesses and respiratory problems.
- Vulnerable populations at higher risk.

ENERGY MIX OF PAKISTAN
POWER SECTOR

Installed Capacity and Generation of Electricity (July-March) FY2023				
Source	Installed Capacity		Generation	
	MW	Share (%)	GWh	Share (%)
Hydel	10,592	25.8	26,937	28.6
Thermal	24,095	58.8	43,526	46.2
Nuclear	3,530	8.6	19,739	21.0
Renewable	2,783	6.8	3,919	4.2
Total	41,000		94,121	



Sectoral Share in Electricity Consumption (July-March) FY2023

Ref: Pakistan Economic Survey 2022-23.

NUCLEAR POWER PLANTS

Reactor Name	Model	Reactor Type	Gross Capacity (MWe)	Construction Start	First Grid Connection
K-1 *	CANDU	PHWR	137	1966-08	1971-10
CHASNUPP-1	CNP-300	PWR	325	1993-08	2000-06
CHASNUPP-2	CNP-300	PWR	325	2005-12	2011-03
CHASNUPP-3	CNP-300	PWR	340	2011-05	2016-10
CHASNUPP-4	CNP-300	PWR	340	2011-12	2017-06
K-2	HPR1000	PWR	1100	2015-08	2021-03
K-3	HPR1000	PWR	1100	2016-05	2022-03
C-5 **	HPR1000	PWR	1200	-	-

*On 1 August 2021, K1 was ceased from its criticality operations and was phased out for its decommissioning, marking the end of its 50-years of operational services.

** CNNC and PAEC signed a cooperation agreement on the construction of a Hualong One reactor as Chashma unit 5.

POWER SECTOR CHALLANGES

- Diversification of Power generation sources.
- Reduction in imported fossil fuel.
- Aging transmission and distribution infrastructure.
- Circular debt.

FUTURE OUTLOOK

- By 2030, aiming to produce 8,800 MWe through Nuclear Power Plants.
- Replacement of ageing fossil fuel based plants with indigenous & renewable energy sources.
- Improving the efficiency and reliability of the existing power infrastructure.
- Construction of hydel power plants have been initiated.
- The reliance on FO for power production is significantly decreased during the last few years.

SMALL MODULAR REACTORS

SMRs can be defined as nuclear reactors with a power output between 10 MWe and 300 MWe that incorporate by design higher modularization, standardization and factory-based construction levels enabling more predictable delivery models based on the economies of series.

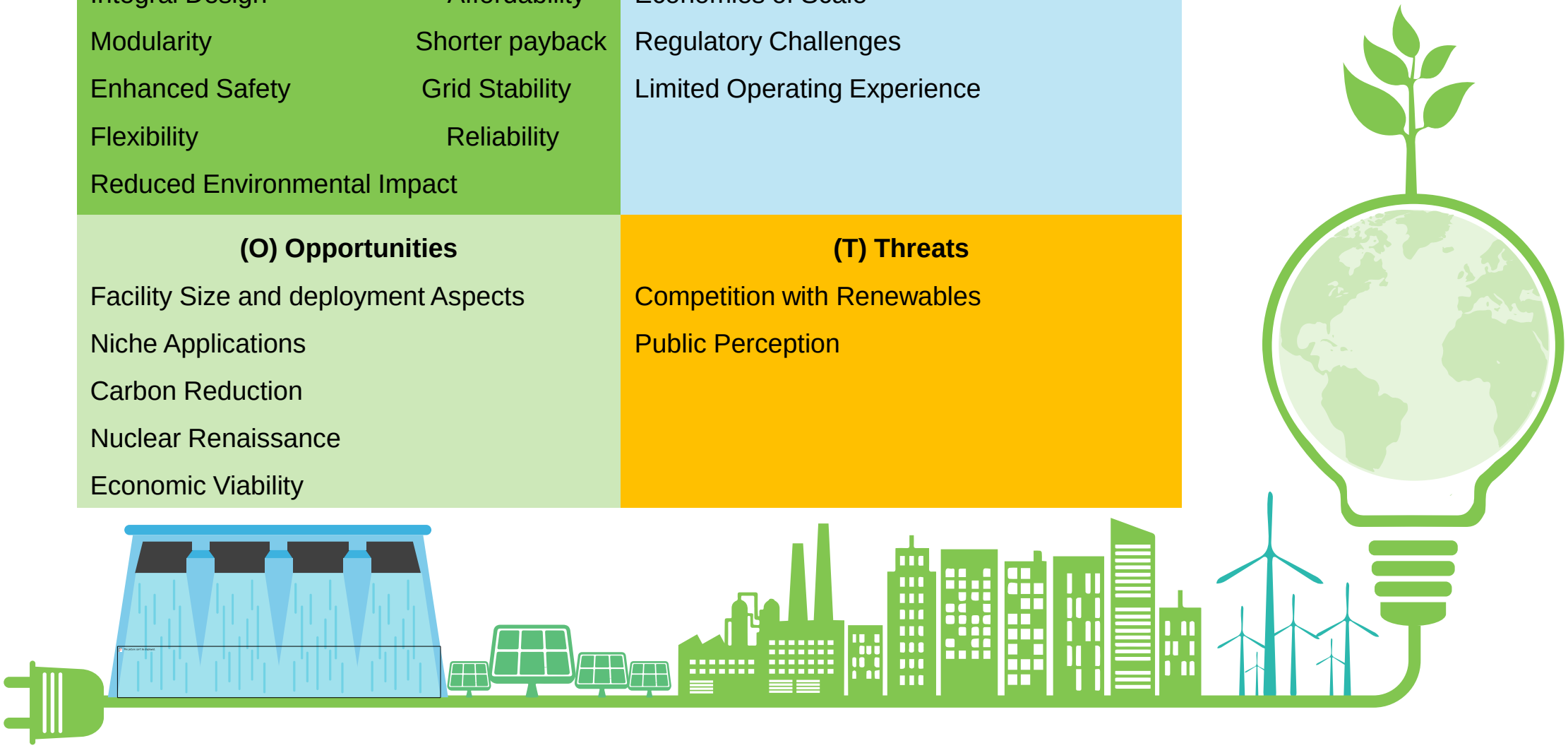
SMRs are being developed in part to expand the market of nuclear power applications beyond traditional baseload electricity provision in a centralized electricity system. At a strategic level, this translates into three overlapping market opportunities:

- Decarbonising energy systems.
- Complementing the deployment of variable renewable energy.
- Facilitating the access of nuclear energy into new sectors and/or regions.

SMR SWOT ANALYSIS

(S) Strength		(W) Weaknesses
Integral Design	Affordability	Economies of Scale
Modularity	Shorter payback	Regulatory Challenges
Enhanced Safety	Grid Stability	Limited Operating Experience
Flexibility	Reliability	
Reduced Environmental Impact		

(O) Opportunities	(T) Threats
Facility Size and deployment Aspects	Competition with Renewables
Niche Applications	Public Perception
Carbon Reduction	
Nuclear Renaissance	
Economic Viability	



SMR-Specific Features

Integral Design	➢ Incorporation of primary system Components into Single vessel. ➢ Elimination of large break LOCA by design. ➢ Elimination of Rod Ejection accident (in case of in-vessel CRDMs) ➢ Increased passivity of decay heat removal.
Modular Design	➢ Factory fabrication, assembling and testing. ➢ Compact Layout. ➢ Fewer Structure, Systems and Components. ➢ Lower On site construction time. ➢ Scalability. ➢ Transportable NPPs.
Safety Aspects	➢ Elimination of some severe accidents by design. ➢ Passive Core cooling for decay heat removal system. ➢ Low Core damage frequency ➢ Longer grace periods due to inherent safety features.
Facility Size and Deployment aspects	➢ Small plant foot print. ➢ Smaller EPZ. ➢ Reduced plant cooling requirements. ➢ Movable or sea based deployment. ➢ Deployment in regions lacking essential infrastructure.
Flexible application	➢ Load following capability enabling cogeneration applications such as desalination, district heating, Hydrogen production. ➢ Suitability for remote regions having small grids. ➢ Integration with renewable in hybrid energy system.
Economic Aspects	➢ Lower upfront cost. ➢ Economy of serial production.

SUSTAINABLE DEVELOPMENT GOALS

Understanding the SDGs

- A universal call for action to end poverty, protect the planet, and ensure prosperity for all.
- Adopted by all United Nations Member States in 2015.

Key SDGs

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. **Affordable and Clean Energy**
8. Decent Work and Economic Growth
9. **Industry, Innovation, and Infrastructure**
10. **Reduced Inequality**
11. **Sustainable Cities and Communities**
12. **Responsible Consumption and Production**
13. **Climate Action**
14. Life Below Water
15. Life on Land
16. Peace and Justice Strong Institutions
17. **Partnerships to achieve the Goal**

The Three Pillars of Sustainability

- **Social:** Eradicating poverty, ensuring good health and well-being, promoting quality education, gender equality.
- **Environmental:** Combating climate change, conserving life on land and below water, ensuring sustainable consumption and production.
- **Economic:** Fostering economic growth, decent work, reducing inequality, promoting industry and innovation.

Why are the SDGs Important?

- Addressing interconnected global challenges.
- Creating a roadmap for a better and sustainable future.
- Ensuring no one is left behind.

POWERING THE FUTURE

- Small Modular Reactors (SMRs) have the potential to provide clean and affordable energy with minimal environmental impact by reducing GHG emissions from power generation to support climate change mitigation and energy security issues.
- Suitability for remote regions installation having small grids and its Integration with renewable in hybrid energy system have the potential of meeting the targets of many SDGs.
- Gwadar could potentially be considered as a location for deployment of Small Modular Reactor (SMR) in Pakistan due to its location and relatively low population density. Desalination using nuclear energy through deployment of SMR is viable as coastal areas facing severe shortage of drinkable water.
- To establish a nuclear facility, an SMR, would require rigorous safety assessments, environmental impact studies, and regulatory approvals.

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5. H. Hidayatullah, S. Susyadi, M. Hadid Subki, “Design and technology development for small modular reactors – Safety expectations, prospects and impediments of their deployment”.
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Thank You