Updates on Saudi National Atomic Energy Project (SNAEP)

Second Meeting of the Technical Working Group for Small and Medium-sized or Modular Reactor (TWG-SMR), 8 – 11 July 2019



Contents

1 Saudi National Atomic Energy Project (SNAEP)

2 Overview on Large Nuclear Power Plants

3 Overview on Small Modular Reactors

4 Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator

5 Overview on SMART Technology (Pre Project Engineering Phase)

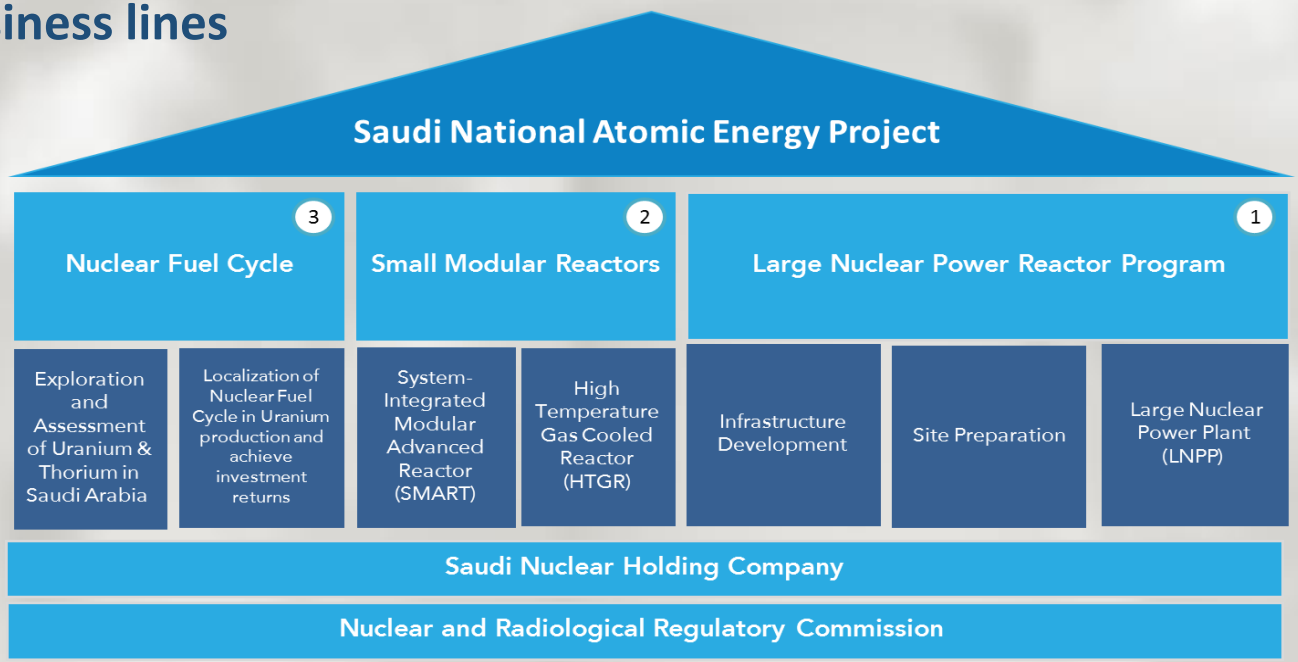
Contents

1	Saudi National Atomic Energy Project (SNAEP)
2	Overview on Large Nuclear Power Plants
3	Overview on Small Modular Reactors
4	Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator
5	Overview on SMART Technology (Pre Project Engineering Phase)

In July 24th 2017, Saudi Government approved the SNAEP to implement a civil nuclear program focusing on three business lines

> *The objectives of National Atomic Energy Program contribute to achieving Kingdom's Vision 2030*
>
> *H.E. MEIM Khaled Al-Falih, Aug 2017*

> *KSA always seeks to take well planned steps to ensure success of the Saudi National Atomic Energy Project as per the international best practices*
>
> *President K.A.CARE, Vienna Sep 2017*



How will the national atomic energy program contribute to Saudi Arabia's energy mix?

Saudi Arabia is increasing its efforts in meeting the growing demands by incorporating alternative sources of energy in its energy mix to reduce the dependence on fossil fuel. Nuclear energy is one of the alternative energy which can assist in the electricity power generation and water desalination.

Notes:

KSA will be establishing a Nuclear Holding Company which will create the future Owner/Operator.

A Charter approved on 13 March 2018 established the Nuclear & Radiological Regulatory Commission (NRRC).

Contents

1	Saudi National Atomic Energy Project (SNAEP)
2	Overview on Large Nuclear Power Plants
3	Overview on Small Modular Reactors
4	Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator
5	Overview on SMART Technology (Pre Project Engineering Phase)

Component 1/1: Large Nuclear Power Plant

- **K.A.CARE continues the Project Preparatory Phase, and currently undertaking the review of the received five Supplier Candidates' responses on 11 deliverables—expecting to finish the evaluation by end of July, 2019.**

- **K.A.CARE has also commenced development of the following elements with support of its PMO Consultant (WorleyParsons);**
  - ✓ ***Integrated Time Schedule***
  - ✓ ***LNPP Bid Invitation Specifications (BIS)/RFP***
  - ✓ ***Program Master Plan using supplier candidates' inputs***



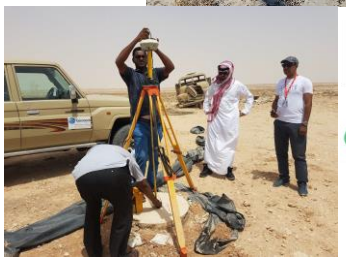




Component 1/2: Large NPP Site Preparation

- **Progress of Technical Field Works**
  Complete Geophysical Investigations & Drilling Program for the primary LNPP site.
- **Approval of Method Statements & Work Plans**
  K.A.CARE with the help of VTT & WP reviewed 58 method statements and work plans for both sites activities as part of the quality control process
- **1st Senior Seismic Hazard Association Committee Meeting**
  K.A.CARE Conducted the 1st Senior Seismic Hazard Association Committee (SSHAC) Meeting with more than 23 Seismic Hazard Analysis Experts
- **Approval of Environmental Impact Assessment Road Map**
  K.A.CARE conducted the 1st Factory Acceptance Test (FAT) at Germany for the Metrological towers




Component 1/3: Infrastructure Development

- **Determined the main components (including SEC scope) of the project and commence development of the Front End Planning and Execution Strategies**

1) Infrastructure Support Facilities;

- Site Development (transportation road network from site area to main road, site layout and allocation of facilities, water and sewage network, etc..)
- Waste water treatment
- Water desalination plant
- Training and simulation center
- Temporary power network and power generation for the construction phase
- Security system specialized for nuclear power plants
- Communication and information system
- Facility protection safety systems (fire protection system and equipment's, etc..)

2) Temporary Facilities (Non Nuclear Facilities Related), Constructing then Operation & Maintenance such as ;

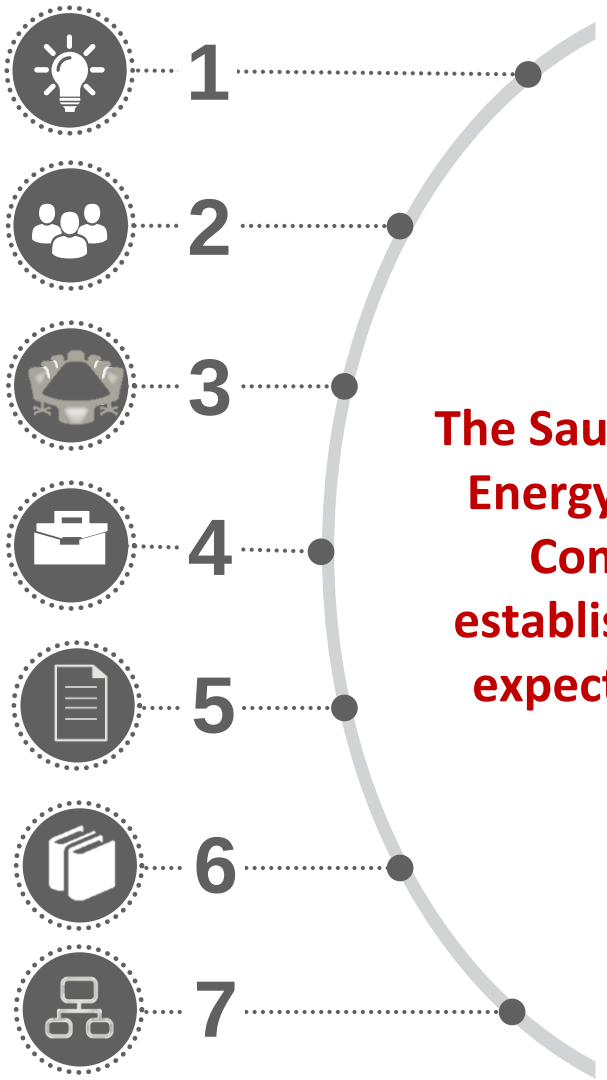
- Fabrication facilities and warehouses for material storage
- laboratories for sampling, measurements and quality control
- Initial stage Power Generation and networks.
- Catering & Accommodation
- Housekeeping, landfill and waste management works

- **Designated team was assigned to the project on April**

- **The project team has approached consultancy company to prepare RFP for Master Plan and Design Services. The RFP will help to define SOW for the Consultancy Engineering Company to develop detail master plan and concept infrastructure design.**

Establishment of Saudi Nuclear Energy Holding Company

1. Review and Revise all previous studies on NHC
2. Conduct Several Meetings with Governmental Companies to capitalize on their lessons learnt
3. Conduct a national workshop with including Governmental Companies to overview their experience in establishing and operating
4. Developing the working scope of the NHC Advisor
5. Finalizing the bylaws for approval in order to issue the required legal framework
6. Prepare and review the Administration and Financial Policies for NHC
7. Develop the Org. structure and Governance Model



The Saudi Nuclear Energy Holding Company establishment is expected soon

Contents

1	Saudi National Atomic Energy Project (SNAEP)
2	Overview on Large Nuclear Power Plants
3	Overview on Small Modular Reactors
4	Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator
5	Overview on SMART Technology (Pre Project Engineering Phase)

Component 2: SMR for KSA

Small Modular Reactor (SMR)
FOR SAUDI ARABIA

Objective

1. Nuclear Cogeneration for Remote cities, Electricity, Water Desalination & Industrial Application
2. Human Capability Building on key Nuclear technology
3. Desire for IP ownership of NSSS (Nuclear Steam Supply System) technology
4. High potential for localization to promote economic growth and job creation in Saudi.
5. Significant greenhouse gas emission reductions
6. Future SMR export market in MENA

Roadmap for the Saudi Atomic Energy Program



Component 2: Small Modular Reactor (SMR)

Methodology for Forming a Strategic Partnership

In keeping with the strategic objective of the KSA, K.A.CARE with regard SMR deployment for electrical power and other non-power applications.

Six Evaluation Criteria have been identified:

1. SMR Mix: Commercial deployment (Technology Readiness) and ways of contribution in the national energy mix.

2. IP Ownership and Tech Transfer: Identify key issues associated with intellectual property (IP) ownership, technology transfer, and joint development in the Kingdom as well as the potential for export market.

3. Human Capacity Development and SMR Value Chain (localization):
   - Consider the long-term human capacity development of SMR technologies in the Kingdom.
   - Consider localization opportunities of SMR value-chain (manufacturing and services)

Component 2: Small Modular Reactor (SMR)

Methodology for Forming a Strategic Partnership

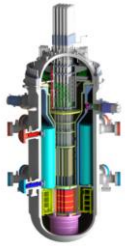
4. SMR Licensing: Examine SMR technologies in light of being licensable in the country of origin as well as meeting the highest international regulatory standards.

5. SMR Deployment: Address the unique siting aspects (i.e., limited cooling water availability, integration with non-power applications) for LWR based SMR designs for deployment in KSA.

6. SMR Economics: Examine the economics and business model for SMR deployment including the Levelized Cost of Energy (LCOE), CAPital EXpenditure (CAPEX) and OPerational EXpenditure (OPEX).

Component 2: Small Modular Reactor (SMR)

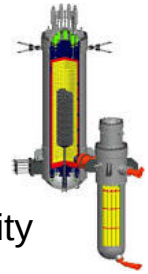
KSA will own and operate small modular reactors for power, water desalination and thermal applications



2/2 SMART

- A complete accomplishment of the SMART PPE design.
- The joint team (K.A.CARE-KAERI) have produced the Preliminary Safety Analysis Report (PSAR).
- There is an IP joint technology ownership between the Kingdom of Saudi Arabia and South Korea.

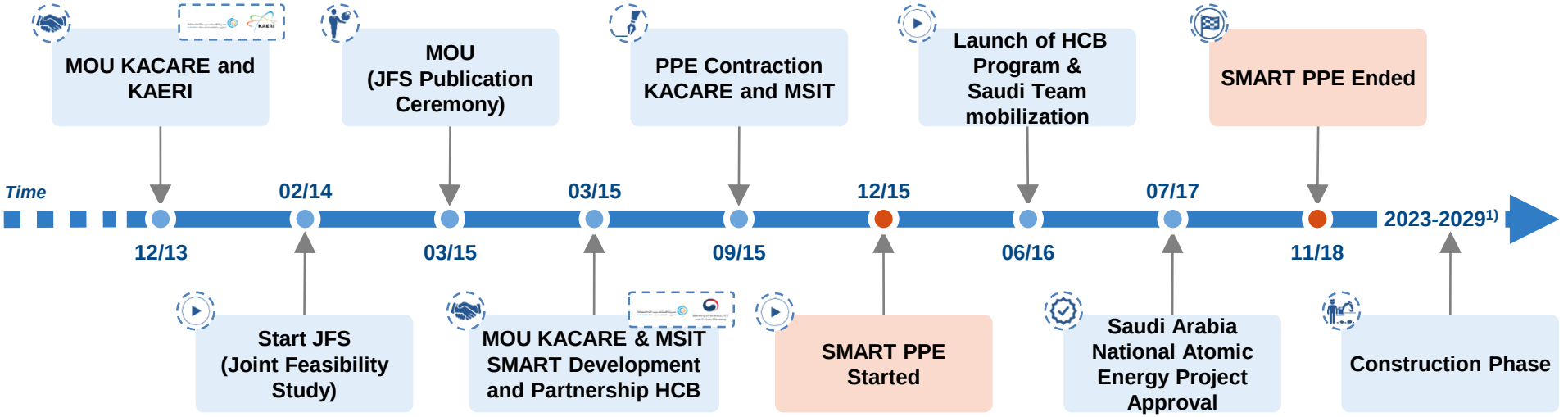
2/1 HTGR



- The Joint Preliminary Feasibility Study was concluded with CNNC in December 2017.
- The key target of this study is to explore long-term strategic partnership with China to own and localize the technology and to support petrochemical and oil refinery industries in KSA.

Component 2: SMART Development

Project Milestone



End of FOAK construction – KSA owns 43% of Integrated SMART IP

Component 2: HTR-PM Cooperation History

January, 2016,

- K.A.CARE and CNEC has signed a MOU to cooperate on the construction of High Temperature Gas Cooled Reactor Project in Saudi Arabia.

March, 2017,

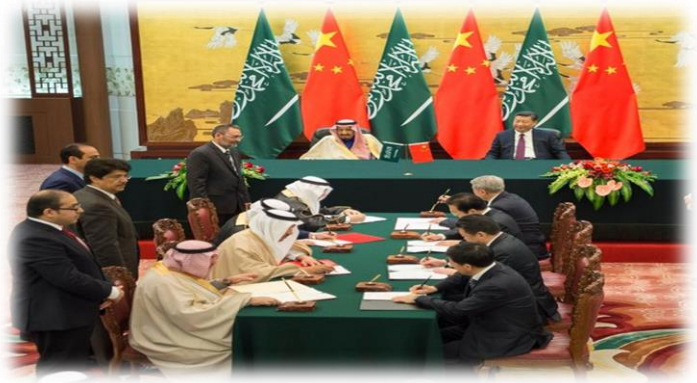
- K.A.CARE and CNEC has signed agreement to contact a feasibility study .

May ,2017,

- K.A.CARE and CNEC has conducted the kickoff meeting in Beijing

December ,2017,

- K.A.CARE and CNEC Concluded the preliminary Feasibility study



Component 2: Small Modular Reactor (SMR)

Localization of SMR technology in KSA is aligned with Vision 2030 and will support the Kingdom in achieving its long term targets and goals

SMR's support to vision 2030



- **Maximize** value captured from the **energy sector**
- **Unlock** potential of **non-oil sectors** & grow non-oil exports
- Develop **human capital** in line with labor market needs
- Grow the **public investment** fund's assets and role as a **growth engine**
- Grow **contribution** of the **private sector** to the economy

SMR program potential contribution			
	SMR technology allows KSA to **better utilize its energy resources** in the long run and meet its **local energy demand** without exhausting its oil reserves	**Knowledge transfer** & training agreements will **enhance local expertise**	SMR value-chain will increase **public & private investment** and **FDI opportunities,** and will help developing potential **local capabilities**

Contents

1	Saudi National Atomic Energy Project (SNAEP)
2	Overview on Large Nuclear Power Plants
3	Overview on Small Modular Reactors
4	Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator
5	Overview on SMART Technology (Pre Project Engineering Phase)

Component 3: Nuclear Fuel Cycle

3/1. Assessment of Uranium and Thorium in KSA

- K.A.CARE is playing the role of quality assurance for all exploration works that is conducted by Saudi Geological Survey (SGS) in collaboration with CNNC across the Kingdom of Saudi Arabia.
- The 1st phase of this national project will be concluded by satisfying the inferred resources of Uranium and Thorium.
- It was mandated by the Royal Decree to cover all suggested exploration areas that is about 27900 Km^2
- The 1st phase of Uranium and Thorium exploration in KSA will be concluded by September 2019






3/2. Uranium (yellow cake) production with Jordan

- K.A.CARE has sent 13 members to Jordan to work on this project on 17th Feb 2019.
- A certain technical committee was formulated by Board of K.A.CARE including all related local stakeholders to oversight the progress of this project.




Component 4: Saudi Nuclear Regulator

Several Decisions were released and announced by Saudi Cabinet of Ministers for followings:

- **Decision number (333) Dated 13th March 2018 approving the National Policy for Atomic Energy in Kingdom of Saudi Arabia**
- **Decision number (334) Dated 13th March 2018 approving the establishment of Saudi Nuclear Radiological and Regulatory Authority**
- **Decision number (405) Dated 10th April 2018 approving the Law of Civil Liability from Nuclear Damages**
- **Decision number (406) Dated 10th April 2018 approving the Law of Regulating the Nuclear and Radiological Uses**
- **Royal Order (14/A) Dated 2nd October 2018 appointing H.E. Eng. Khalid Alfalih as the Board's Chair of Saudi Nuclear Radiological and Regulatory Commission**
- **Royal Order (27318) Dated 24th January 2019 appointing Dr. Khalid Aleissa as the CEO of Saudi Nuclear Radiological and Regulatory Commission**

Contents

1	Saudi National Atomic Energy Project (SNAEP)
2	Overview on Large Nuclear Power Plants
3	Overview on Small Modular Reactors
4	Overview on Nuclear Fuel Cycle & Saudi Nuclear Regulator
5	Overview on SMART Technology (Pre Project Engineering Phase)

PPE Project Status

- SMART Preliminary Safety Analysis Report (PSAR) was completed.
- SMART PPE deliverables which contain 4378 design documents were issued.
- Human Capacity Building (HCB) program was completed and 36 KACARE engineers were qualified for NSSS design and have contributed in the design document generation.
- KACARE have reviewed and checked all SMART PPE deliverables. VTT have worked to support KACARE in SMART – Safety Confirmatory Analysis and HCB program quality as an independent reviewer
- SMART PPE is in the final closing stage

VTT Engagement in SMART - Confirmatory Analysis to ensure design safety

- Develop SMART simulation model using Apros & Serpent
- Review essential design documentations
- Review Licensing Documents: Preliminary Safety Analysis Report (PSAR) and Preliminary Accident Management Program (PAMP)
- Licensing Workshop with Saudi regulator at STUK in Finland (Mar. 2018) – discussed licensing plan, SDCA, PSAR and Site

VTT final report on confirmatory analysis has been drafted with conclusion that Safety confirmatory was assured

2	2.1	2.1.1	Cross sections for Apros model and Serpent reference solution,
		2.1.2	Apros SMART core model,
		2.1.3	Evaluation of the need of the confirmatory analyses on core shielding design,
	2.2	2.2.1	Modelling of fluid systems,
	2.3	2.3.1	Analyses of HFE documentation,
		2.3.2	Analyses of Human System Interface (HSI) designs,
	2.4	2.4.2	Material properties and structural integrity of the RVA,
	2.5	2.5.1	Review of Safety Analysis Methodology for SMART,
		2.5.2	Core transient safety analysis,
		2.5.3	Combined core and circuit Apros analyses,
		2.5.4	Fuel behaviour safety analysis,
		2.5.5	Severe accidents analyses,
		2.5.6	Licensing requirements and PSAR response to them,

Path Forward

- KACARE & KAERI plan for SMART technology licensing agreement.
- KHNP & VTT recommendations are important tool for the future of SMART technology validation and commercialization.
- Currently KACARE is conducting review on SMR project strategy. A committee has been formed to review SMR projects and give recommendation on path forward.

SMR over all development

- Challenges are almost well known: Licensing, sitting, etc..
- All of these challenges best addressed with a decision for FOAK.
- Country to take advantage of FOAK
- OR through IAEA a multi-country effort to build FOAK.



مدينة الملك عبد الله للطاقة
الذرية والمتجددة K.A.CARE

Thank You