

The Moroccan NPP Project and Partnerships Perspectives

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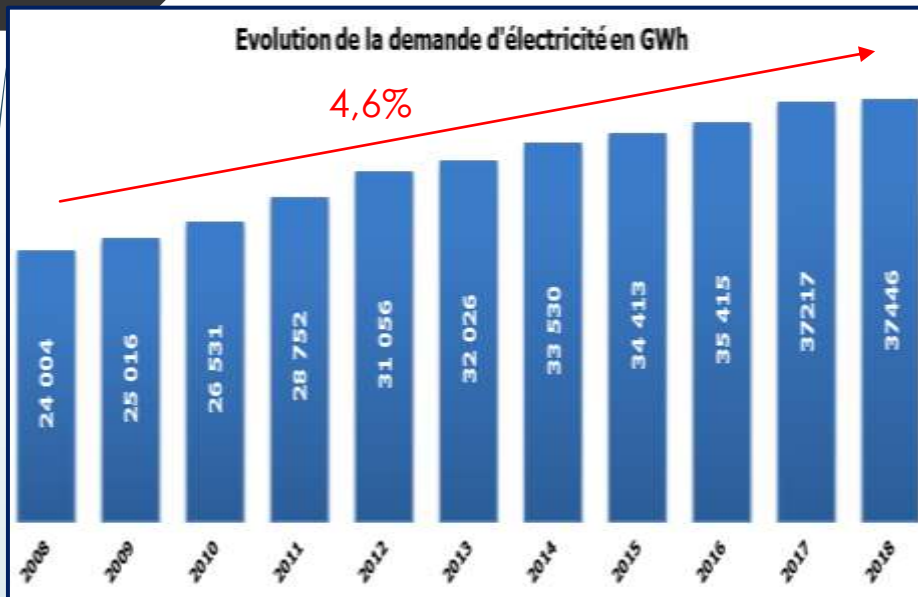
MOROCCO

● **SUMMARY:**

- ❖ **Moroccan Energy System Evolution**
- ❖ **The Moroccan NPP Project phases**
- ❖ **The IAEA Milestones Approach & INIR Mission**
- ❖ **The Maamora Nuclear Research Center**
- ❖ **The Regulatory & Legislative framework**
- ❖ **The partnerships perspectives in NPP project**

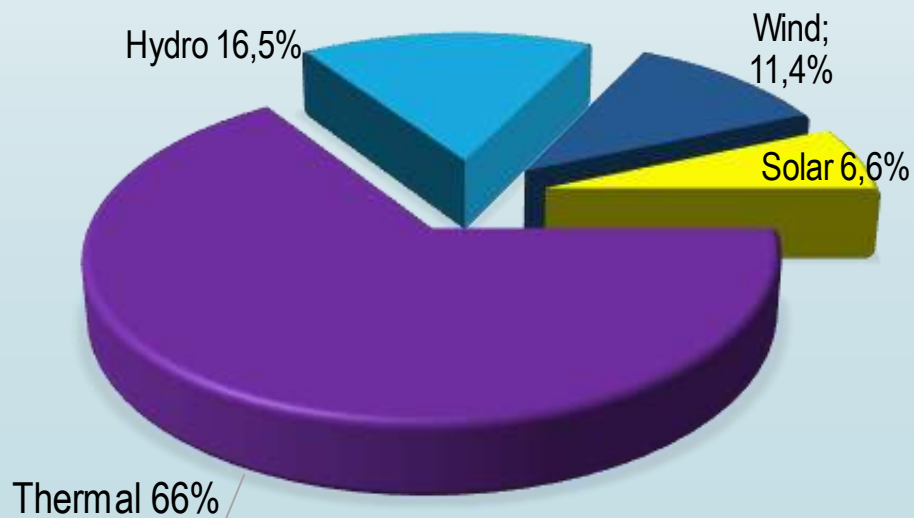
MOROCCO: A GROWING ELECTRICITY DEMAND

Average Growth
Rate: 4,6%



General Data (2019)

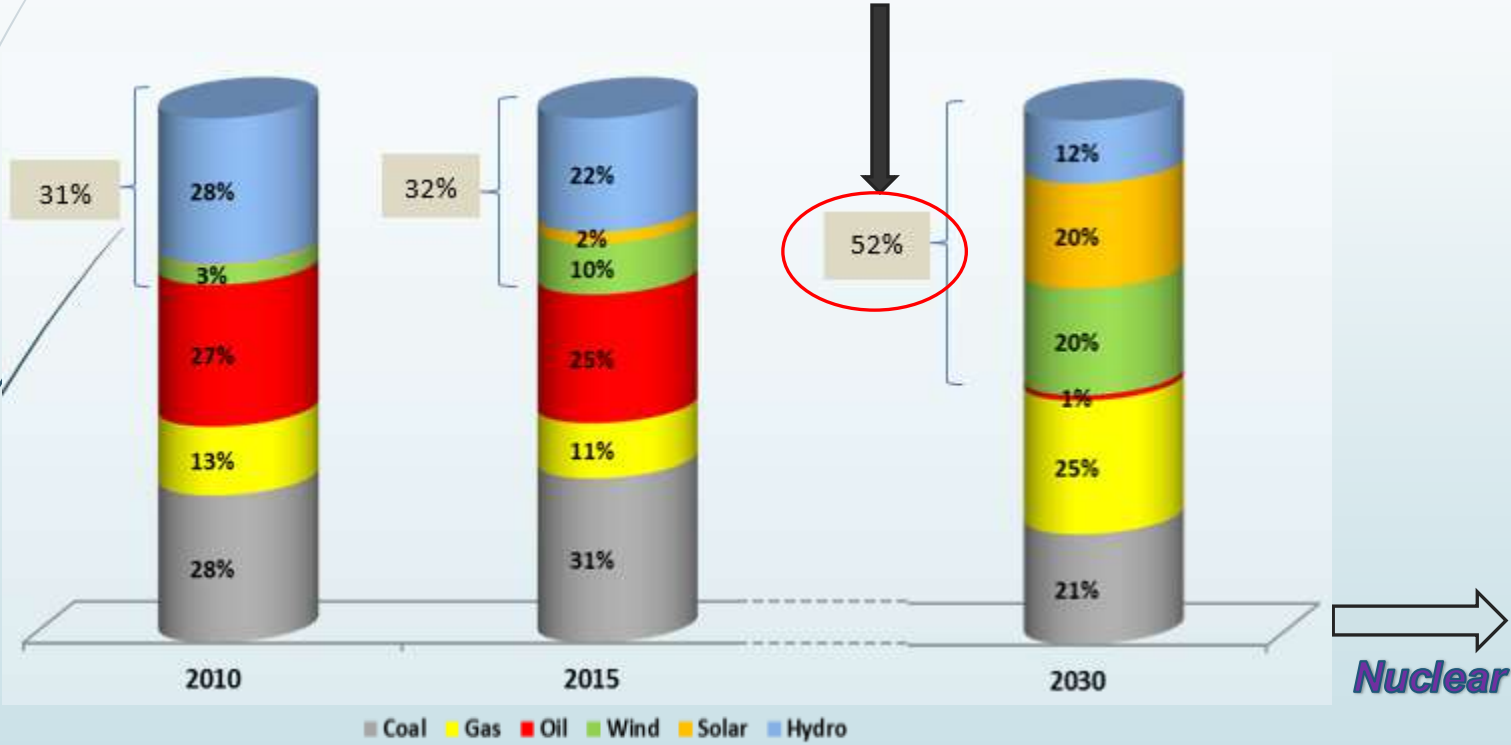
- ❑ Total Installed Capacity : **10677 MWe**
- ❑ Demand average growth rate : **4,6%**
- ❑ Energy consumption : **40 348 GWh**
- ❑ Rural Electrification Rate: **99,7%**
- ❑ Installed Interconnection Capacities:
 - ❑ 1400 MW With Spain
 - ❑ 2400 MW with Algeria



**Installed capacity by
energy source (2019)**

The Moroccan Energy Mix Evolution

Forecasted Renewables Energy Penetration Rate in 2030



THE MOROCCAN NUCLEAR POWER PROJECT

1- The First Feasibility and Sites Study (1984-1995)

- ❑ The first Feasibility Study to introduce a first NPP in Morocco was undertaken by the National Utility **ONEE** with the services of the French Consultant **SOFRATOME** and with **IAEA** assistance;
- ❑ A very exhaustive sites studies lead to the choice of the **Sidi Boulbra site**, located at Atlantic Sea between SAFI and Essaouira cities (300 km in the south of Casablanca), as the appropriate site with no **characteristics that would prevent the construction of an NPP units under the safety requirements. This conclusion was validated by IAEA mission Experts.**
- ❑ A detailed studies in many NPP areas (technical, economical, regulatory, organizational, ..) have been done and thousands reports have been written, including a detailed **Technical Specifications** of the NPP and the Preliminary **Site safety Report.**
- ❑ **The results of these study has show that :**
 - 1) *The national electrical network (at that time) could not support the operation of the large power of proven Standardized technology, mainly the PWR 900 MWe*
 - 2) *The Nuclear Option was not competitive with the scenario of reference based on Coal power plant of 600 MWe*
 - 3) *The required NPP infrastructures for implementing an NPP project was not completed (Regulatory and legal framework, HR Capacity Building, ...)*

THE MOROCCAN NUCLEAR POWER PROJECT

2- The Feasibility of Nuclear desalination with China (1997-2000)

- ❑ A bilateral convention between Morocco and China was signed and a technico-economic feasibility has been realized based on small nuclear reactor for **seawater desalination** production in the south of Morocco (Tantan City),
- ❑ The technology proposed was the Chinese **NHR (Nuclear Heating Reactor)** with two power ranges : 10MWth and 200 MWth.

The main results of this study has shown that we could produce potable water with competitive cost.

THE MOROCCAN NUCLEAR POWER PROJECT

3- Updating the First Feasibility and Sites Study (2003-2004)

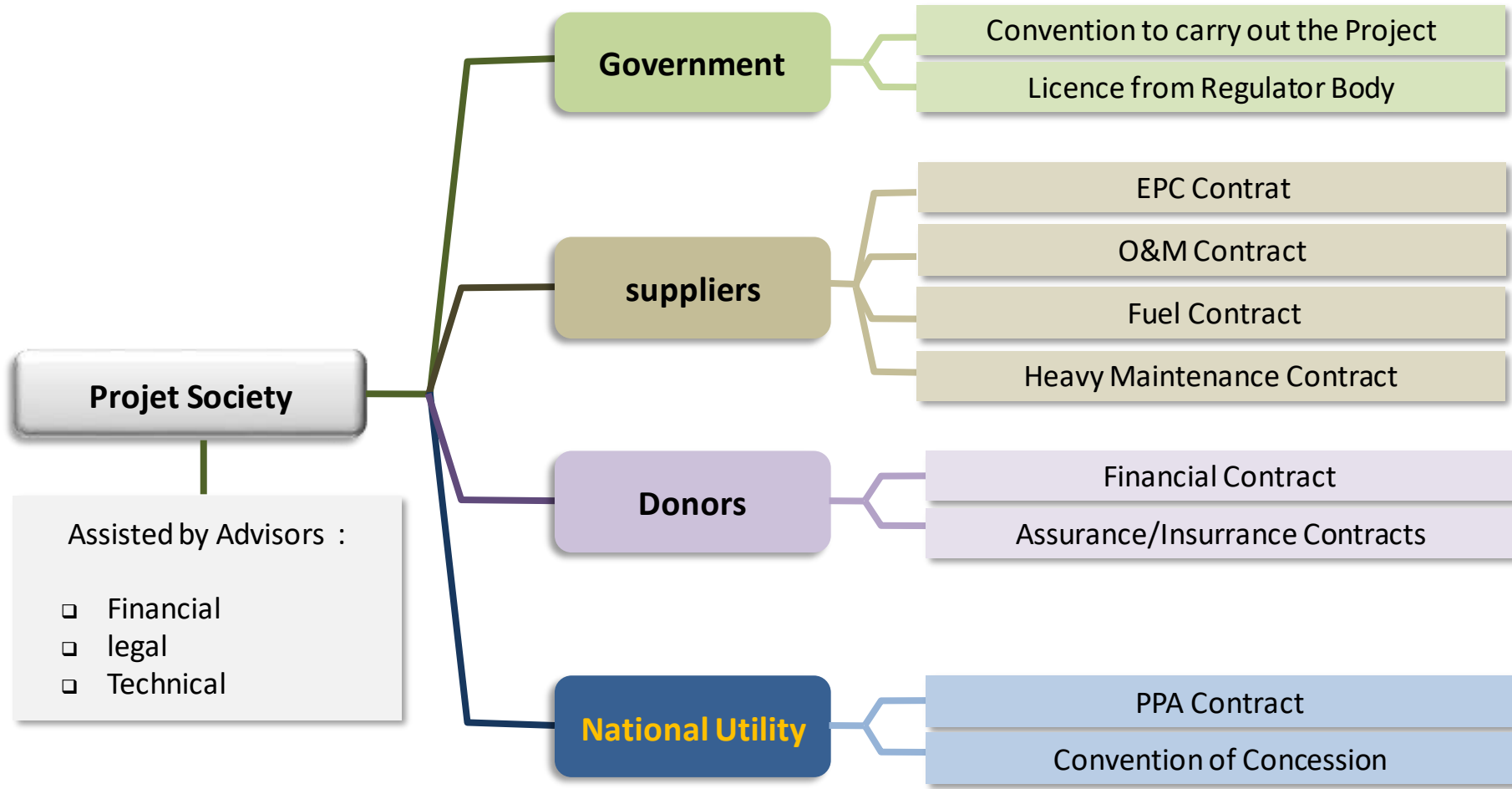
- ❑ The volatility of primary fossil energy prices and the high dependence of these energy sources lead the National Utility ONEE to update the first NPP feasibility study ;
- ❑ These work was undertaken by a **dedicated ONEE team** with the IAEA assistance;
- ❑ The results, **validated by IAEA**, shown the feasibility and the competitiveness of Nuclear Option and lead to the choice of **Proven & commercially available** Nuclear Reactor technology, mainly **PWR 1000 MWe, VVER-1000 MWe** and **CANDU-6 of 700 MWe** to be implemented in Morocco ;
- ❑ The updated Sidi Boulbra site characteristics still presents several positive aspects related to safety and external environmental risks.
 - ***Main issue: due to higher cost of fossil sources (coal), the nuclear option was a viable option to be implemented in Morocco at the horizon of 2017-2020.***
 - ***Based on these result, ONEE decided to launch a small or light Tender by contacting the main nuclear reactor technology suppliers and operators in an Non Bidding Process***

4- The Non Binding Process (2006-2007)

- In 2006-2007, The National Utility ONEE has undertaken a preselecting process inviting the constructors and operators of different NPP technologies types selected during the updated FS, to submit a non binding offers related to
 - 1) the construction of **two** NPP of **700 to 1000 MW each**,
 - 2) the operation & maintenance of the units
 - 3) The heavy maintenance of the units
 - 4) the services related to nuclear fuel supply
- This process has been implemented in order to have a good visibility about the technology offered and the kWh prices before taking the decision,
- **AECL (CANDU-6 700 MWe), AREVA (PWR 1000 MWe), ATOMSTROYEXPORT (VVER-1000)** and **KHNP/DOOSAN (OPR 1000 MWe)** have submitted offers,
- During this process, ONEE has been supported by an international technical consultant and an international legal consultant for their assistance during the bids evaluation and for reviewing and completing the draft project contracts prepared by ONEE,
- the Bid Invitation documents (EPC contract, O&M contract, Fuel supply contract, PPA contract) have been established.

This exercise was to be continued by a bidding process but it was not the case because the other required NPP infrastructures were not completed. This is why we go forward to review and asses the required NPP infrastructures with IAEA (INIR mission) and consider an NPP Program.

CONTRACTUAL SCHEME PROPOSED IN THIS NON BIDDING PROCESS



IAEA Milestones Approach and INIR Mission

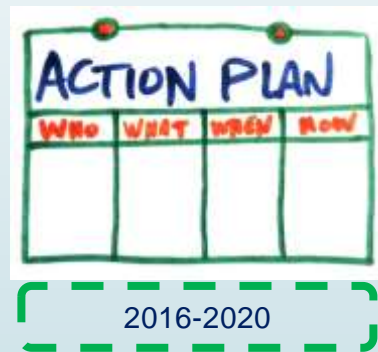
In response to the recommendation of the IAEA Milestones approach (19 Infrastructures issues) , the Ministry of Energy of Morocco has set up, in 2009, a national committee called **(CRED)**, equivalent to the IAEA's Pre-NEPIO (Preliminary Nuclear Energy Implementing Organization). The CRED has representatives from various Moroccan organizations and institutions **(Ministry of Energy, National Electricity and Water Utility, Maamora NRC, Regulatory Body, Ministry of Health, Nuclear engineers association, University,..)**

- Since its setting up, the CRED has organized itself into several working groups (WGs) and has produced two national Self Evaluation Reports (SERs). The latter report (2014) has served as the basis for the conduct of **the IAEA's INIR mission (Rabat 19-26 October 2015)**.



INIR mission and Integrated Work Plan (IWP)

- The INIR mission report found that Morocco has **developed base of knowledge and experience in nuclear activities in its preparation to make knowledgeable decision** about introducing nuclear energy in its electrical system (**phase 1** : take a knowledgeable decision).
- **17 main recommendations** were issued by IAEA experts
- A **IWP** has been drawn over the period **2016-2020** and the work has been carried out by the CRED's WG's to implement these IAEA recommendations and to prepare a **Comprehensive Report** summarizing the key elements for supporting the National Decision.



The Comprehensive Report (Phase 1) should be finalized **current 2021 for Supporting National Decision**



Phase 2 ?

The National Center For Nuclear Energy, Science And Technology (CNESTEN) and the The MAAMORA Nuclear Research Center (Maamora NRC)

CNESTEN

Established in 1986 with the following missions :

- Managing the Nuclear Research Center of Maamora (based on **Triga Mark II 2MW research reactor** and its associated laboratories),
- Developing scientific research in nuclear science and technology,
- Promoting nuclear applications in socio-economic sectors (Nuclear medicine, Agriculture, Water resources, Industrial applications,...)
- Contributing to the development of infrastructure for a nuclear power program
- Acting as a Technical Support Organization (TSO) for national authorities,
- Managing radioactive waste at national level.

Maamora NRC : more than 20 years of operating experience



Expertise in different activities :

- Nuclear Medicine and life sciences (Production of radioisotopes)
- Industrial Applications Natural Resources & Environment applications
- Safety & Security
- Radioactive Waste Management
- Research & Development
- Training
- National Support Training Center in Nuclear Security field with International assistance (IAEA, US DOE)
- National Support Training for Emergency Preparedness and Nuclear Security (Emergency Response exercises, Nuclear Security exercises, ..)
- Availability of a Research Reactor as powerful tool for training (Universities)
- A **new Training Center** in Nuclear Science and Technology was constructed and is **operational** in the Maamora NRC

1999-2002: Construction of laboratories and associated facilities

2004-2006 : Construction of the **TRIGA Mark II 2MW** Research Reactor

Regional Training Center in the fields of radiation protection, Isotope hydrology, Industry and Nutrition (IAEA-AFRA)

National Center for NDT training and certification

National Support Training Center in Nuclear Security field with International assistance (IAEA, US DOE)

National Support Training for Emergency Preparedness and Nuclear Security (Emergency Response exercises, Nuclear Security exercises, ..)

Availability of a Research Reactor as powerful tool for training (Universities)

A **new Training Center** in Nuclear Science and Technology was constructed and is **operational** in the Maamora NRC

THE REGULATORY AND LEGISLATIVE FRAMEWORK

1- The Regulatory framework :

- ❑ A new National **Nuclear Law (Loi 142-12)** on nuclear safety and nuclear security has been promulgated in 2014.
- ❑ In the framework of this law, **an independent Nuclear Safety Authority**, called "**Agence Marocaine de Sûreté, Sécurité Nucléaire et Radiologique**" (**AMSSNuR**) has been established in 2016, with authority and financial support from government (With almost 100 personnel staff).
- ❑ At present, This Regulatory Body is finalizing the required package of regulatory texts in the nuclear activities **including NPP installations** and with the collaboration of the national organizations concerned. The main texts has been submitted to the Government for approval (Nuclear Safety policy, Decree related to licensing and safety of Nuclear installations of Category 1, Decree related of radioactive waste and spent fuel safety, decree related to physical protection of nuclear installations and nuclear materials, decree related to Safeguards, decree related to Emergency Response,..) .

2- Main International Conventions and Treaties ratified by Morocco.

Morocco has ratified almost the main International Conventions and Treaties related to nuclear energy field:

- ✓ NPT and IAEA Safeguards,
- ✓ Additional Protocol,
- ✓ Physical protection convention and its amendment,
- ✓ Nuclear Civil liability Convention ; convention in reparation on nuclear supplementary damages,
- ✓ Nuclear safety Convention,
- ✓ Joint convention on spent fuel and radioactive waste management,

Partnerships perspectives in the Moroccan NPP project

- ❑ The primary conclusions of national energy planning study shows that using **Large PWR GIII NPP (1000 -1200 Mwe)**, the **nuclear option is not part of the solution at the lowest cost** that could be implemented in Moroccan electric system due to the high capital cost of these NPP (≈ 4000 to 5000 US\$/kW);
- ❑ On the other hand, there are many incentives for thinking about **Small Modular Reactors (SMR's)** in Morocco, such as:
 - ✓ *less expensive in terms of investment cost,*
 - ✓ *high safety levels,*
 - ✓ *more flexible in terms of power incrementation,*
 - ✓ *suitable for cogeneration,*
 - ✓ *Positive impact on technology transfer & national industrial participation,*
 - ✓ *positive environmental impacts, ...etc.*

Partnerships perspectives in the Moroccan NPP project

- ❑ To explore new alternative strategies for development of nuclear energy with enhanced sustainability, especially with **SMR's option**, Morocco decided to be is an **Observer Member** in :
 - ✓ **the IAEA Technical Work Group for SMR's (TWG-SMR)**
 - ✓ **the INPRO ASENES SMR's Project ,**
 - ✓ **Participant in IAEA CRP for SMR's economics**

- ❑ *The Partnerships of NPP Program implementation would be possible if :*
 - ✓ *The **National Position is** in favour of the nuclear power option (at least for introducing Nuclear power in the energy mix diversification)*
 - ✓ *The **competitiveness** of the nuclear power option against the other Energy sources, especially Gaz & Renewables, **should be a strong incentive***
 - ✓ *What should be the choice of suitable **organizational /contractual scheme** of the NPP project or NPP program (IPP or classic scheme ?) ...*

Partnerships perspectives in the Moroccan NPP project

- Anyway, the Technical Cooperation with IAEA are **continuous** task in order to prepare and support the National Position and also for completion of the other NPP infrastructures assesment such as Capacity Building of Human Ressources and Nuclear Regulatory Framework completion.
- The **Nuclear Research Center of Maamora** have established many partenrships with many regional and international organisations and is recognized as a **Center of Excellence** by IAEA in some fields (Radiation protection Training, Water ressources..).
- The **Moroccan Safety Authority** is finalizating the nuclear regulatory package and had established many bilateral and regional/international cooperation with other regulatory bodies.