International Conference on

small modular reactors

and their applications

21–25 October 2024, Vienna, Austria

ENABLING FACTORS FOR SMR UPTAKE IN BOLIVIAN FUTURE POWER SYSTEM

C. MARIANI, N. STEVANATO, S. LORENZI, M.E. RICOTTI

Politecnico di Milano

H. JIMÈNEZ RIVERA, M. HERBAS

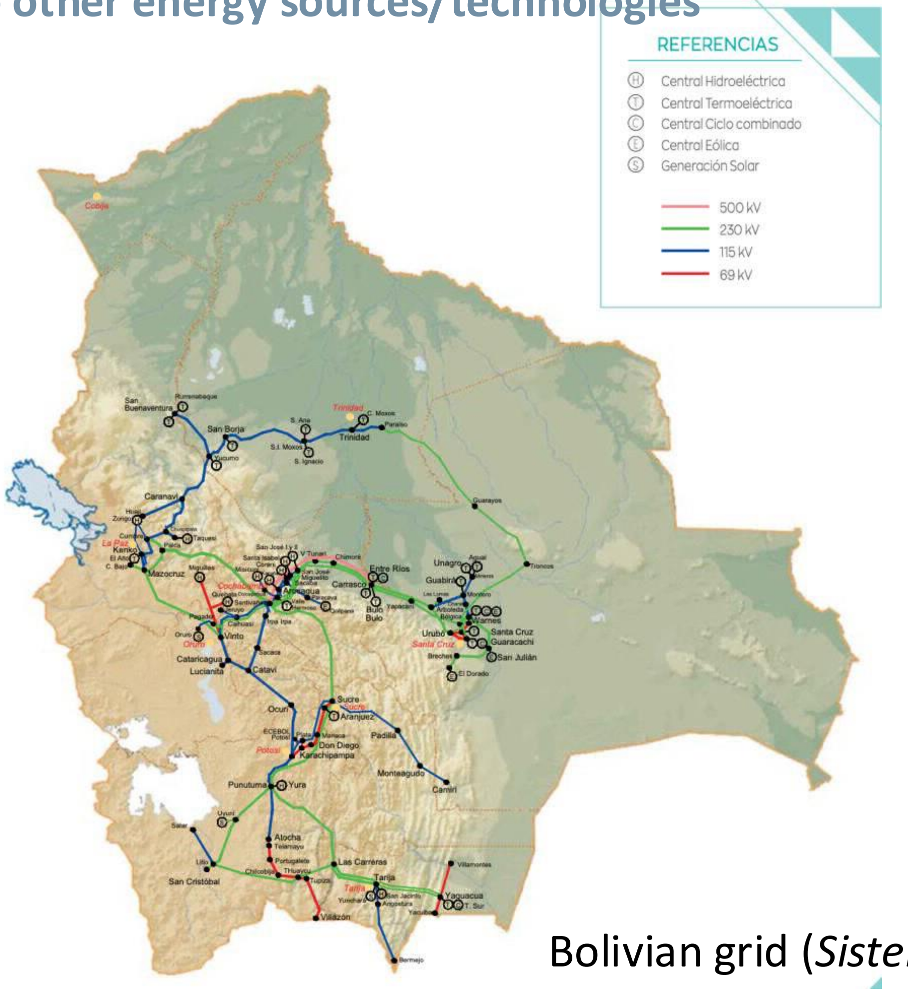
Agencia Boliviana de Energia Nuclear

SMR in Bolivia: energy scenarios

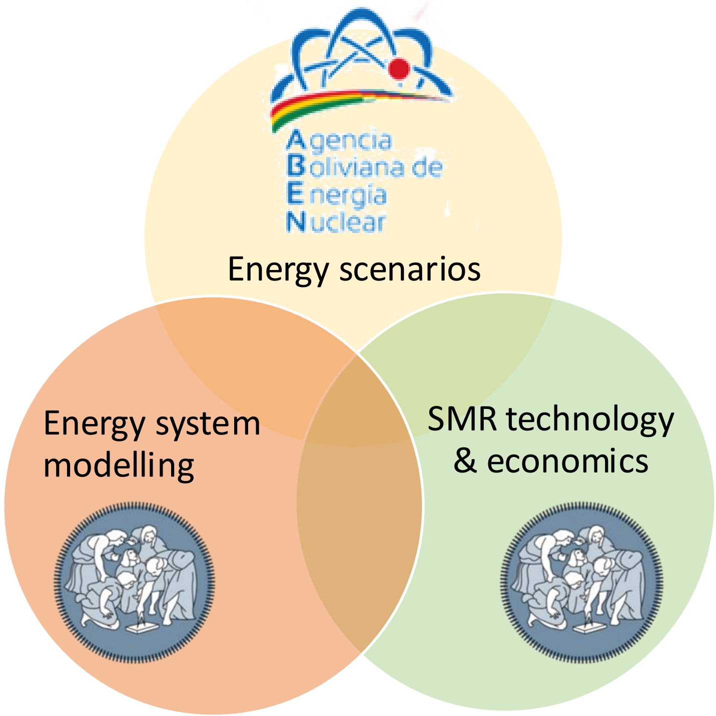
Objective

- Analyse the feasibility of introducing SMR in the Bolivian energy mix in 2035, evaluating if nuclear power turns out to be economically competitive compared to other energy sources/technologies

Bolivian regions



Bolivian grid (*Sistema Interconectado Nacional*)



SMR in Bolivia: the tool

Calliope

- Energy System Optimisation Model
- free and open-source tool
- easy-to-build energy system models
- scales ranging from urban districts to entire continents

Inputs

Locations
Load Demands
Existing Technologies
Transmission lines
Techno-economic parameters
Constraint parameters

Calliope

Calliope

Outputs

Capacity Factors
Carrier Produced
Costs
Capacity Installed

SMR in Bolivia: the method

Focus:

- **Optimizing the hourly dispatch of the energy system in a short time horizon in the operation mode**

or

- **Optimizing the new required capacities for a snapshot of the future in a planning mode.**

Two modes of optimization:

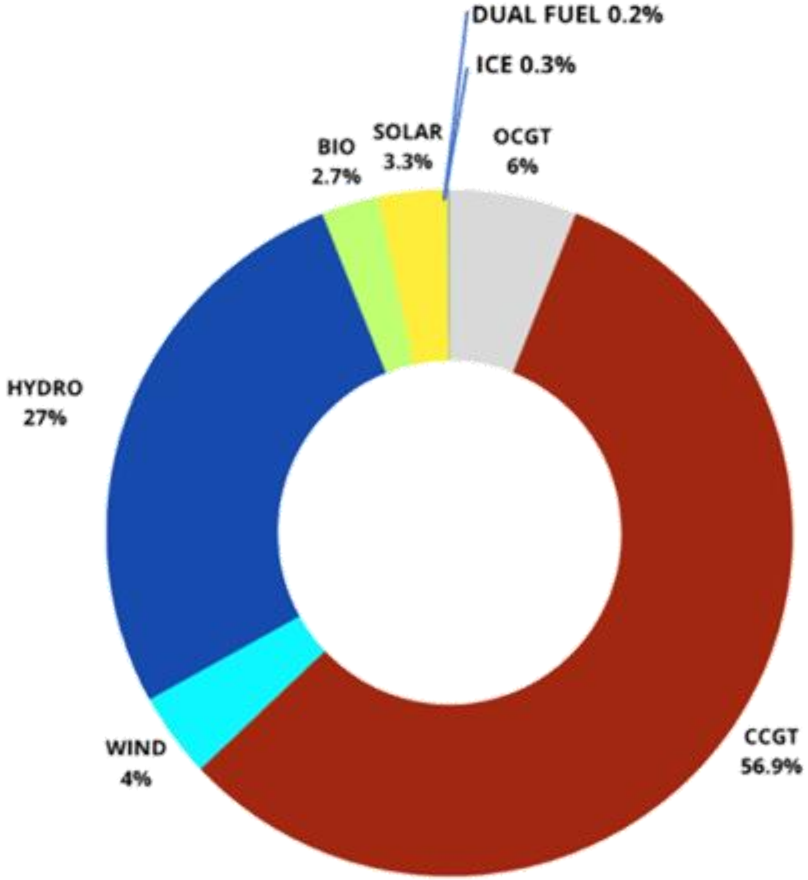
- **Operation: optimizes the dispatch of the existing system at the moment being, to fulfil the given load**

- **Planning: optimizes the installation of new plants, combining with already existing ones, to fulfil a given load**

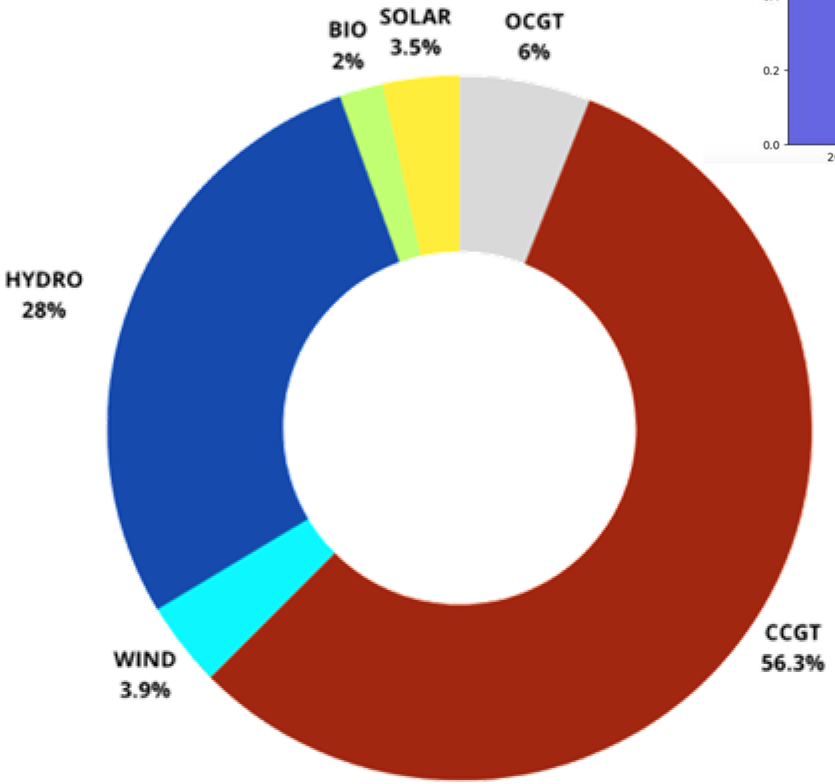
SMR in Bolivia: the "validation" (2022)

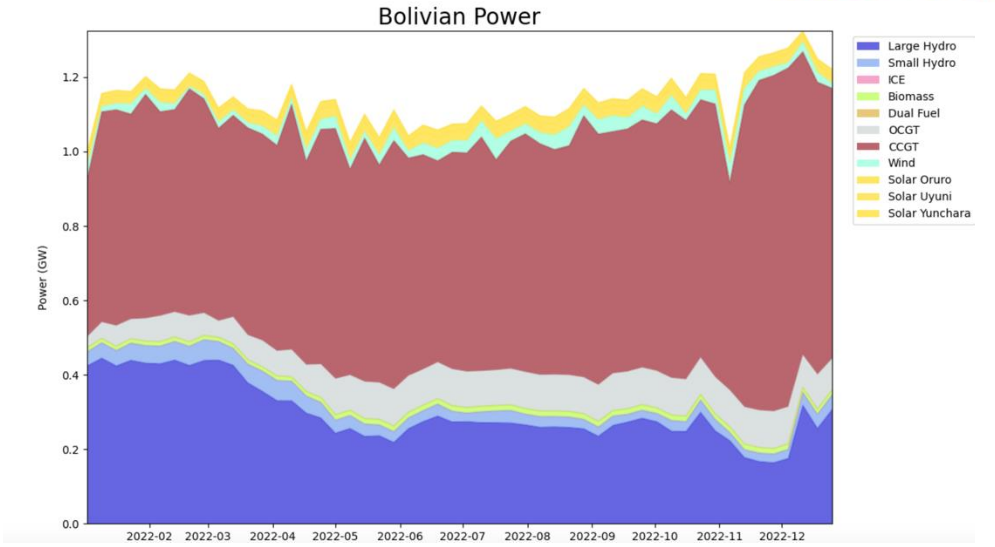
OPERATION mode (given Load demand, given Installed power)

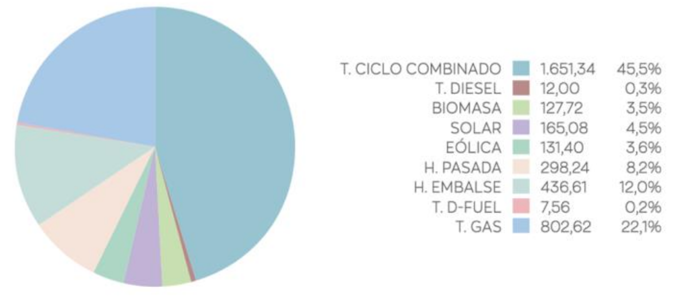
2022 – Real scenario [Comité Nacional de Despacho de Carga]



2022 – Calliope optimization



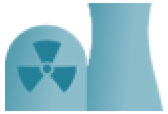




Installed power (2022)

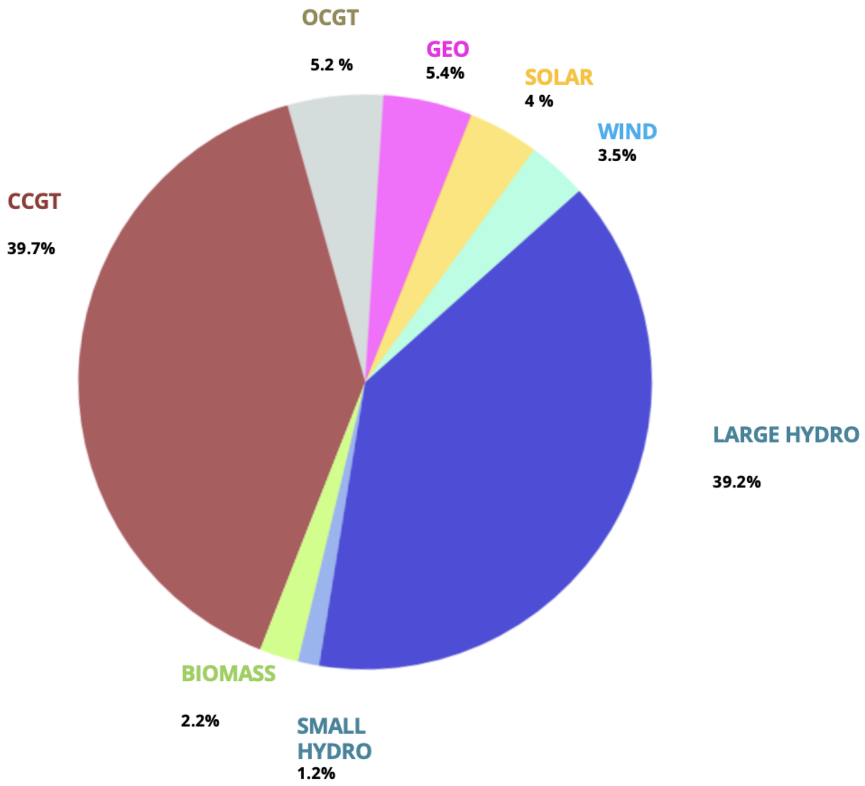
SMR in Bolivia: scenario#1 (2035)

PLANNING mode (forecasted Load demand +4%/y, constraints on new Installed power according to Bolivian Energy Plan, potential build of SMRs)

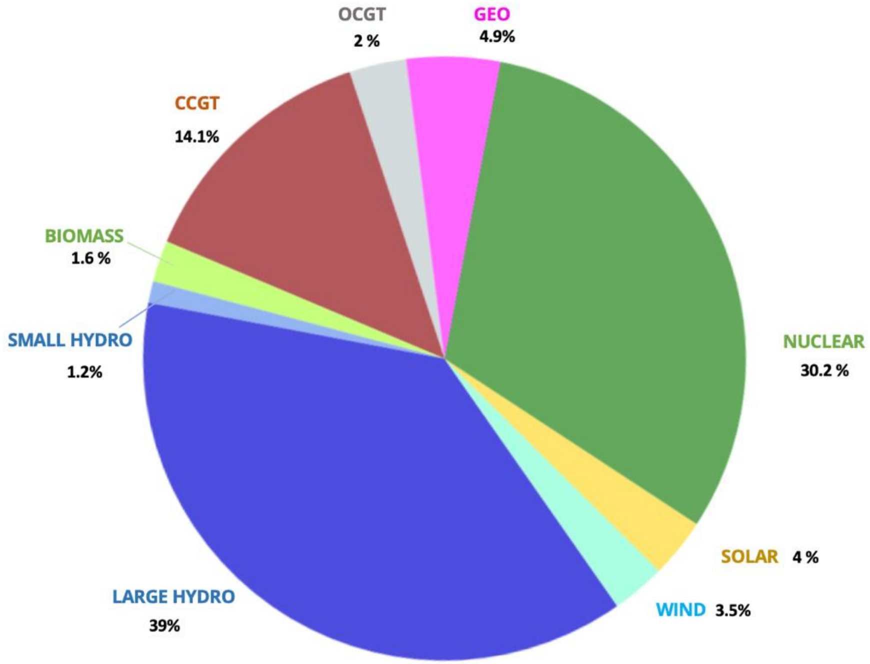


SMR

Parameter	Value
Overall Efficiency	**0.32**
Lifetime	**60 y**
Min Cap Factor	0.2
Max Installable Units	**3**
Unit Capacity	**340 MWe**
Spec Investment Cost	**6000 $/kW**
Discount rate	**5%**
Fix O&M	95 $/kW y
Var O&M	0.003 $/kWh
Cost of Fuel	0.001 $/kWh$_{th}$



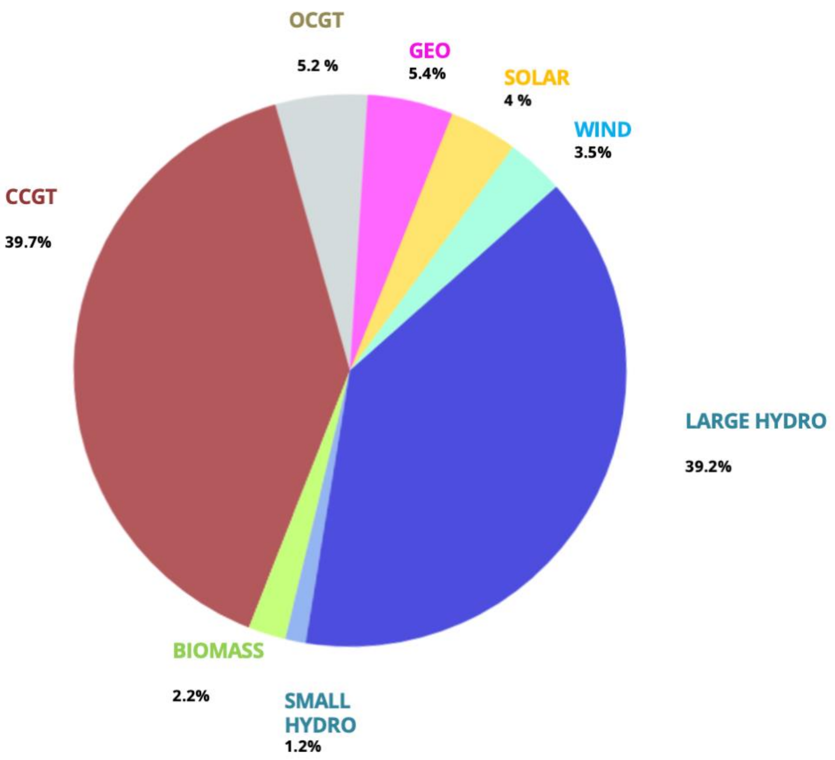
2035 – No Nuclear



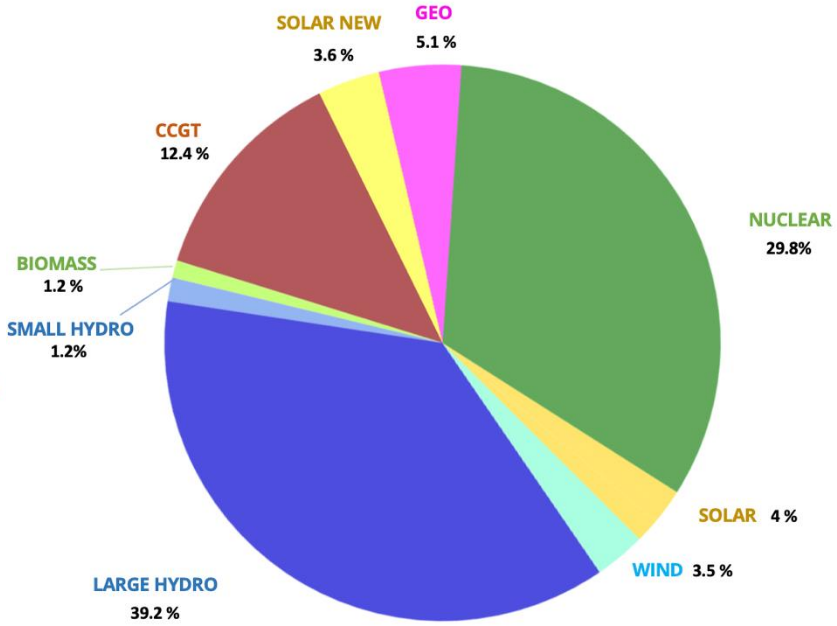
2035 – scenario#1 with free Nuclear
2 SMRs (680 MWe) in the optimised scenario

SMR in Bolivia: scenario#2 (2035)

PLANNING mode (forecasted Load demand +4%/y, no constraints on new Installed power Renewables + SMRs)

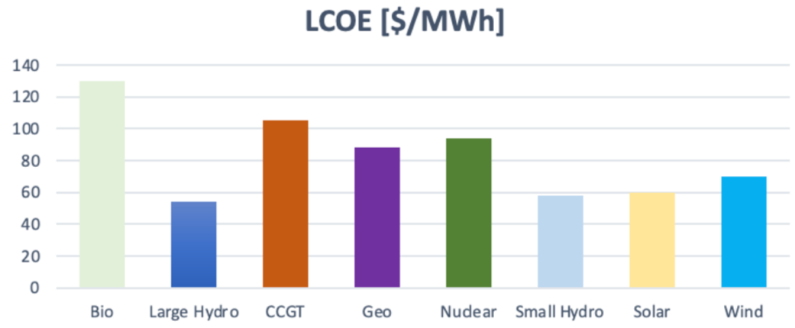


2035 – No Nuclear



2035 – scenario#2 with free Nuclear + Renewables
2 SMRs (680 MWe) in the optimised scenario

2035 – SECOND SCENARIO			
	TWh produced	MW installed	Capacity Factor
CCGT	2	1651.3	0.19
BIO	0.19	120	0.21
SMALL HYDRO	0.17	77.26	0.52
LARGE HYDRO	6.6	3400	0.50
WIND	0.5	266	0.21
SOLAR	0.6	265	0.26
NUCLEAR	4.8	680	0.80
GEO	0.8	105	0.87
NEW SOLAR	0.5	240	0.25

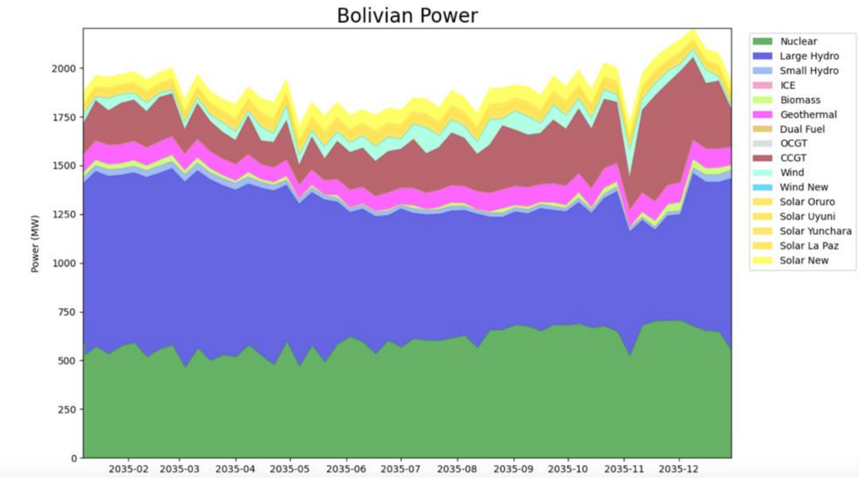


SMR in Bolivia: sensitivity analysis

SENSITIVITY ANALYSIS

Multiple runs by varying interest rate and investment costs to see when nuclear power is cut out of the energy mix

INTEREST RATE	Investment costs [$/kWh]				
-	6000	8000	10000	12000	13000
5%	2 SMRs	2 SMRs	2 SMRs	1 SMR	NO
7%	2 SMRs	1 SMR	NO		
9%	1 SMR	NO			
10%	1 SMR	NO			
11%	NO				



SMRs as a competitive base-load energy source

Interest on cogeneration mode (Lithium extraction, Salar de Uyuni)