1st MENA Energy Economics Conference

# Impacts of energy efficiency policies on the integration of renewable energies - Case Study of the Tunisian Electricity System -

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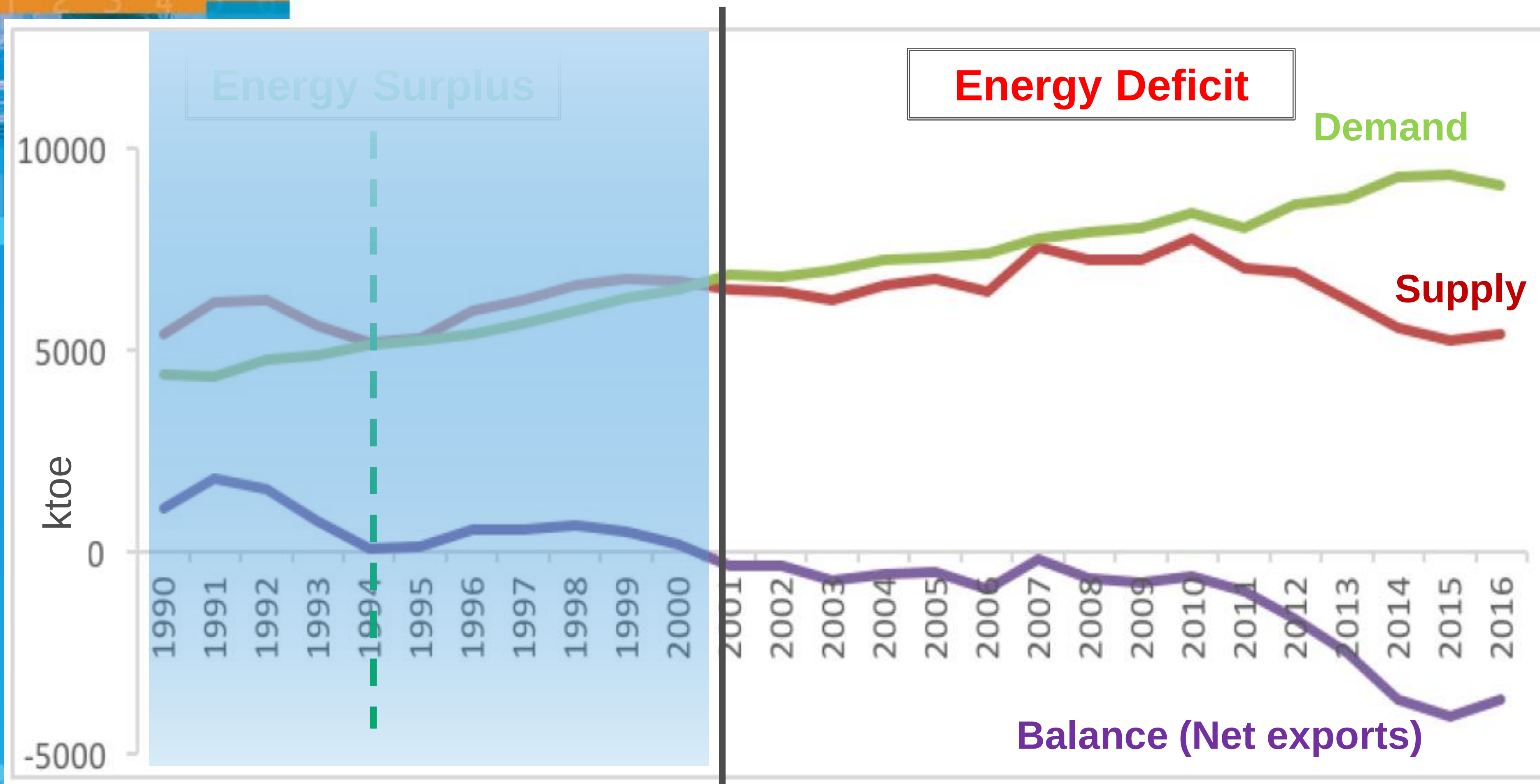
# Energetic Situation in Tunisia

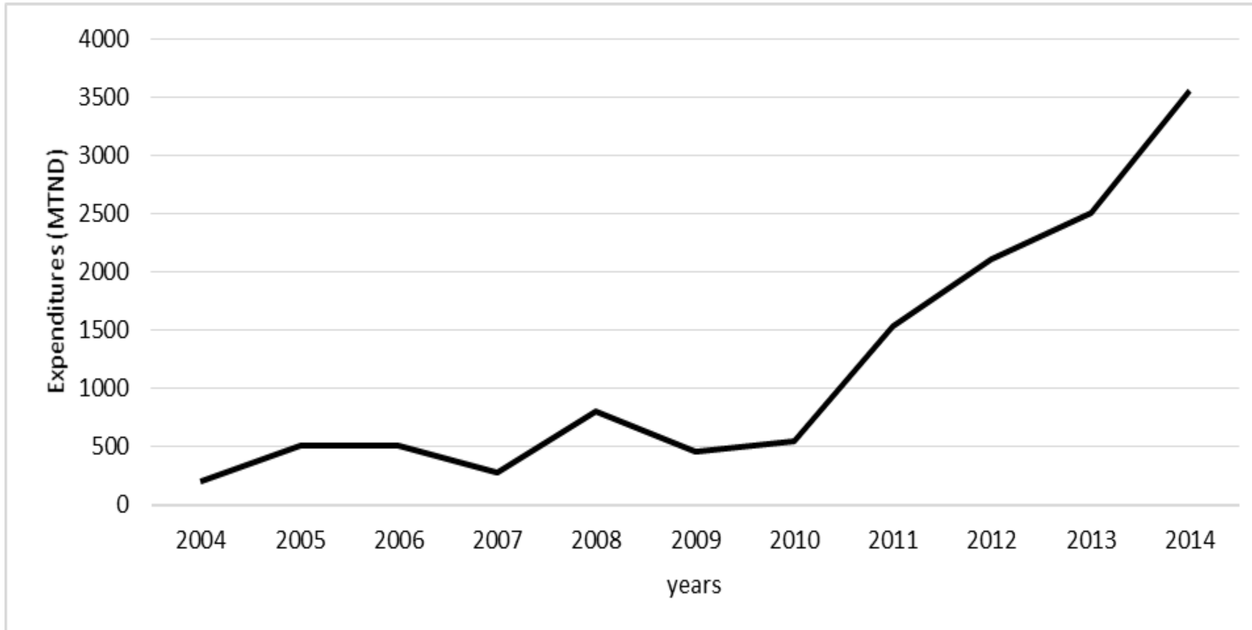
## Evolution of Energy Balance




Source : ONE


# Energetic Situation in Tunisia

## Energy Subsidies



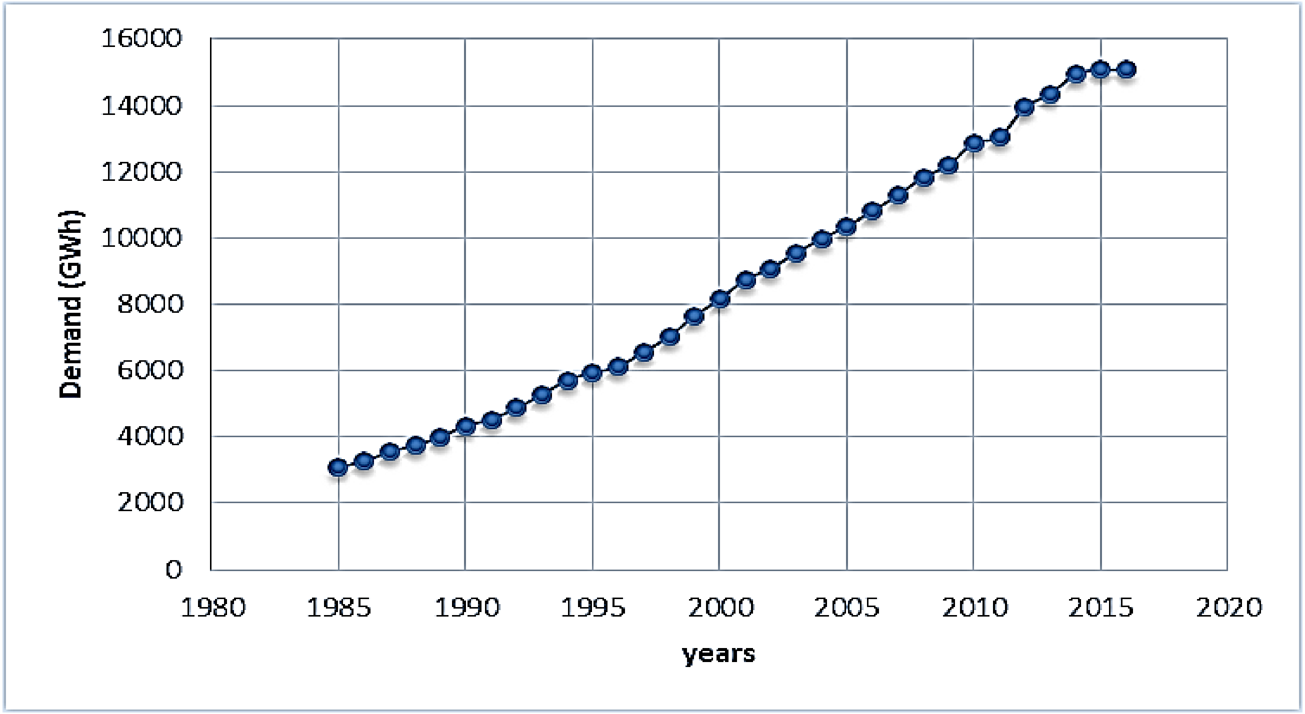

Governmental direct subsidies for energy sector

The global subsidies in 2013: ≈ 5300 MTND,

- 43% are allocated for oil products,
- 41% for electricity,
- 16% for natural gas,
- 0.9% for energy conservation.


# Energetic Situation in Tunisia

## Evolution of Electricity demand

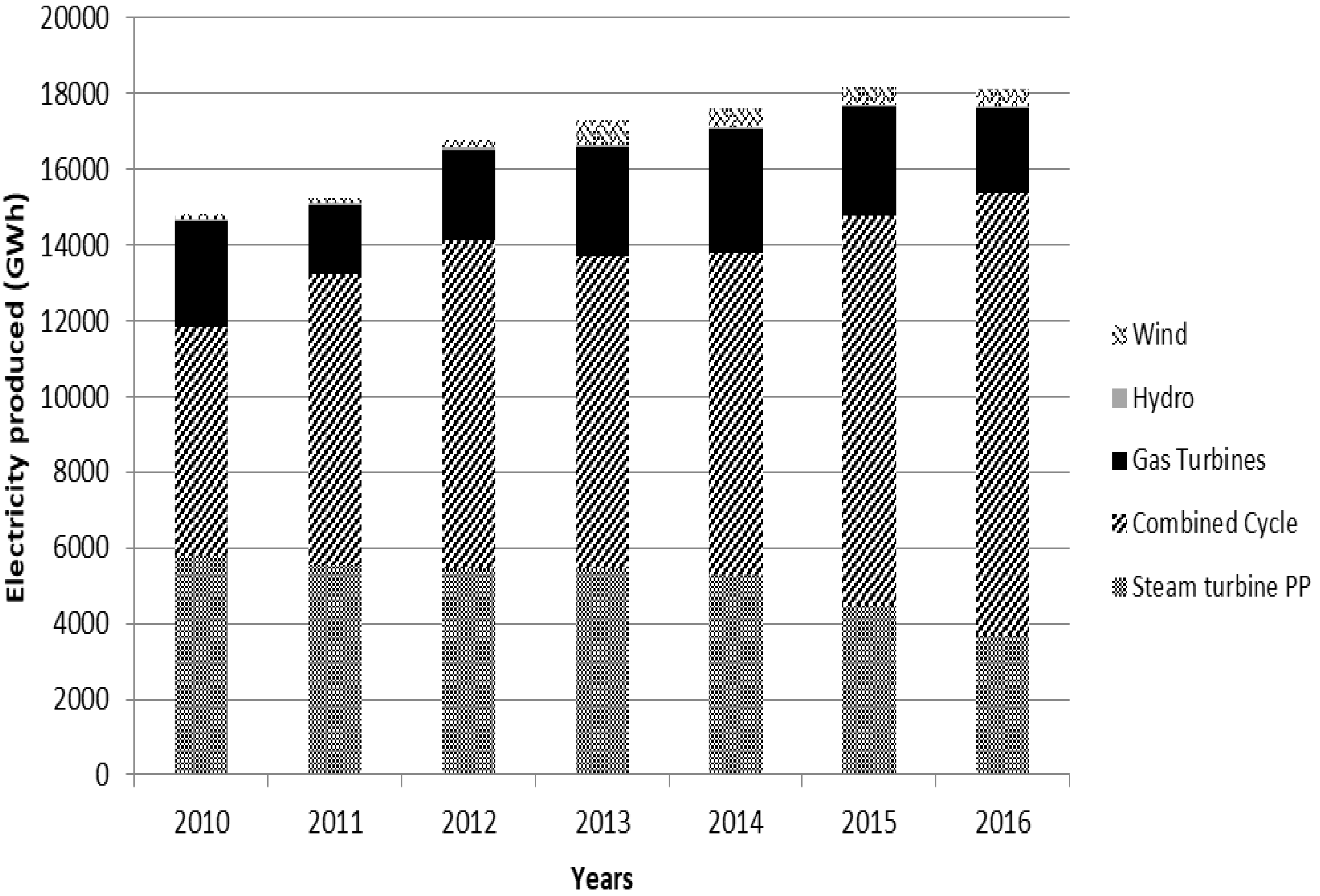



Evolution of the net national electricity demand 1985 – 2016

Rate of annual growth of electricity demand during the last three decades: ≈5%.
National electricity demand In 2016: 15079 GWh

# Energetic Situation in Tunisia

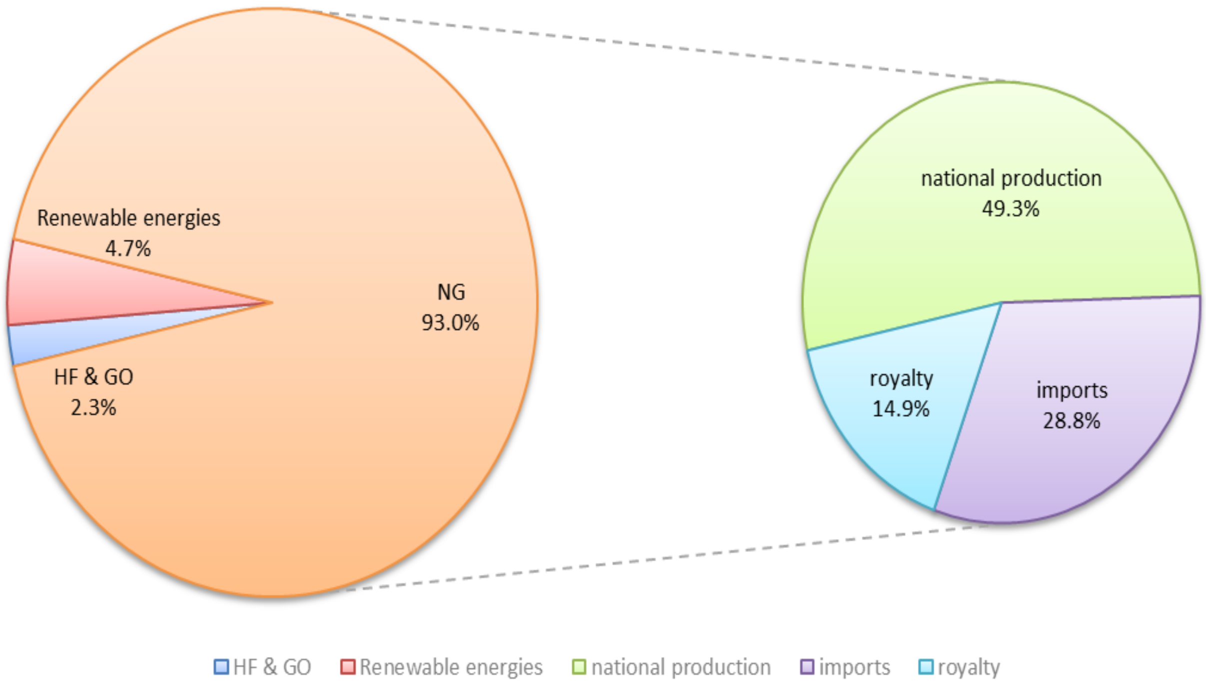
## Electricity Mix




Evolution of the Electricity Mix


# Energetic Situation in Tunisia

## Electricity Mix




Primary energy utilisation for electricity production in 2014

→ Dependency on fossil fuels (Natural Gaz)


# Energetic Situation in Tunisia

## Main characteristics

- Big deficit in the primary energy balance
- Large amount of subsidies (≈ 5300 MTND in 2013)
- High level of electricity demand (15079 GWh in 2016) and high rate of growth (5%)
- Electricity Mix based on fossil fuels (93% NG)

Need for energy transition

- More Energy Efficiency
- More Renewable energies

**How? How much? Which kind of RE?**

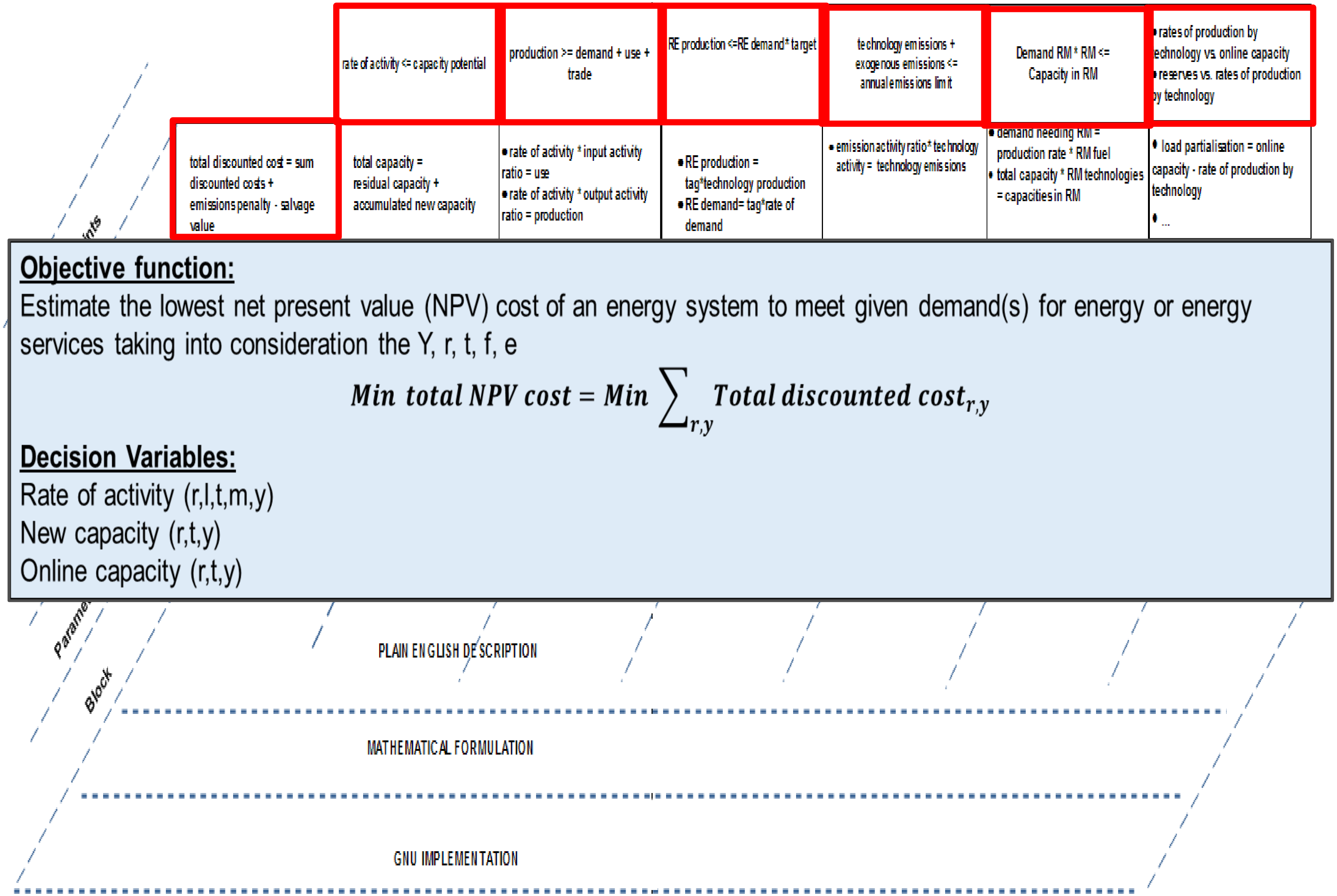
**……**


# Tunisian Electricity System Modeling

## Modelling Tool: Open Source Energy Modelling Systems "OSeMOSYS"

- A bottom-up, dynamic and linear optimisation model
- Aims to calculate the lowest net present cost of an energy system to meet given demands.
- The demands for energy are met by technologies competing against each other and defined by a set of economic, technical and environmental parameters and policy goals
- It is used for long-term energy planning by developed and developing economies' researchers and governments
- The mathematical language used for simulating the model is Gnu Math-Prog using the solver GLPK.

# Tunisian Electricity System Modeling




**Objective function:**

Estimate the lowest net present value (NPV) cost of an energy system to meet given demand(s) for energy or energy services taking into consideration the Y, r, t, f, e

$$Min\ total\ NPV\ cost = Min \sum_{r,y} Total\ discounted\ cost_{r,y}$$

**Decision Variables:**

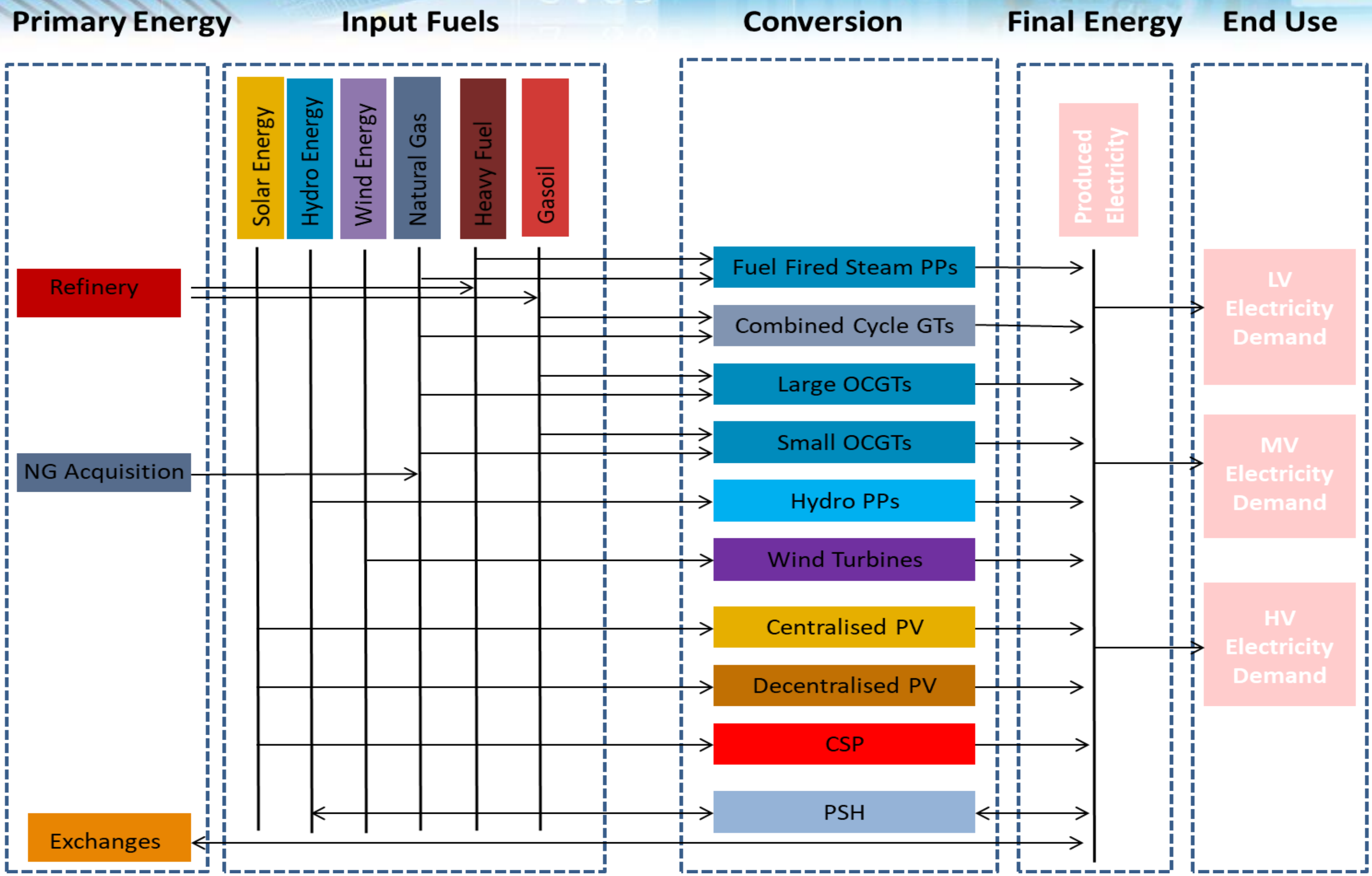
Rate of activity (r,l,t,m,y)

New capacity (r,t,y)

Online capacity (r,t,y)

# Tunisian Electricity System Modeling

## Reference Energy System



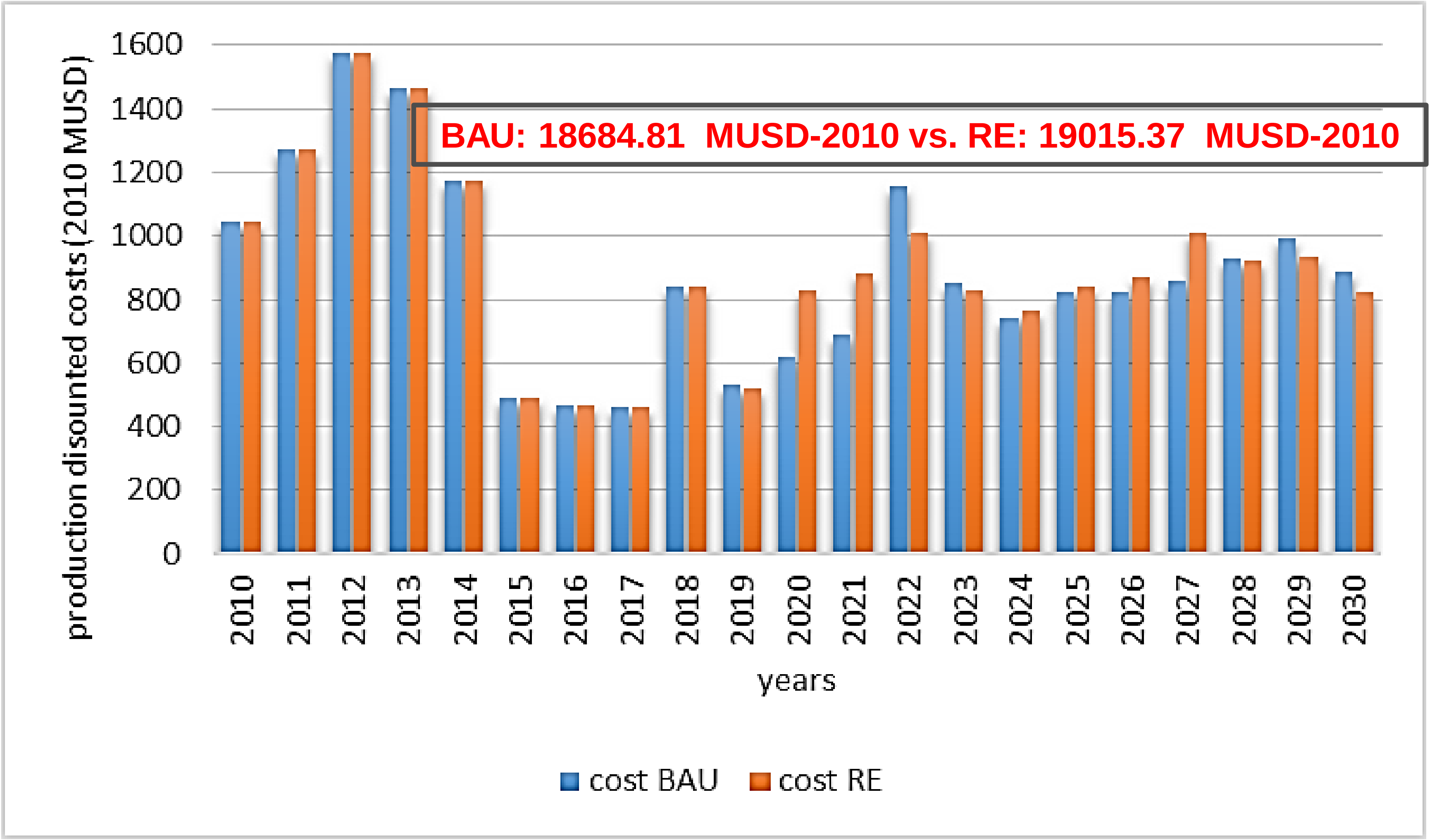
# Tunisian Electricity System Modeling

Main assumptions

| | |
|---|---|
| **Time domain** | **2010 to 2030** |
| **Time slices** | 16, weekdays and weekends, day and night for three seasons and Ramadhan |
| **Existing technologies** | NG fired Steam PPs, CCGTs, OCGTs (large and small capacities), wind turbines, hydro power plants, decentralised PV and onshore interconnections |
| **Future technologies** | CCGTs, OCGTs (large capacities), wind turbines, decentralised PV, Centralised PV, CSP, PSH, and onshore & offshore interconnections |
| **Considered Scenarii** | BAU scenario:<br>• 5% of electricity generation by 2030<br>RE scenario:<br>• 30% of renewables by 2030 |

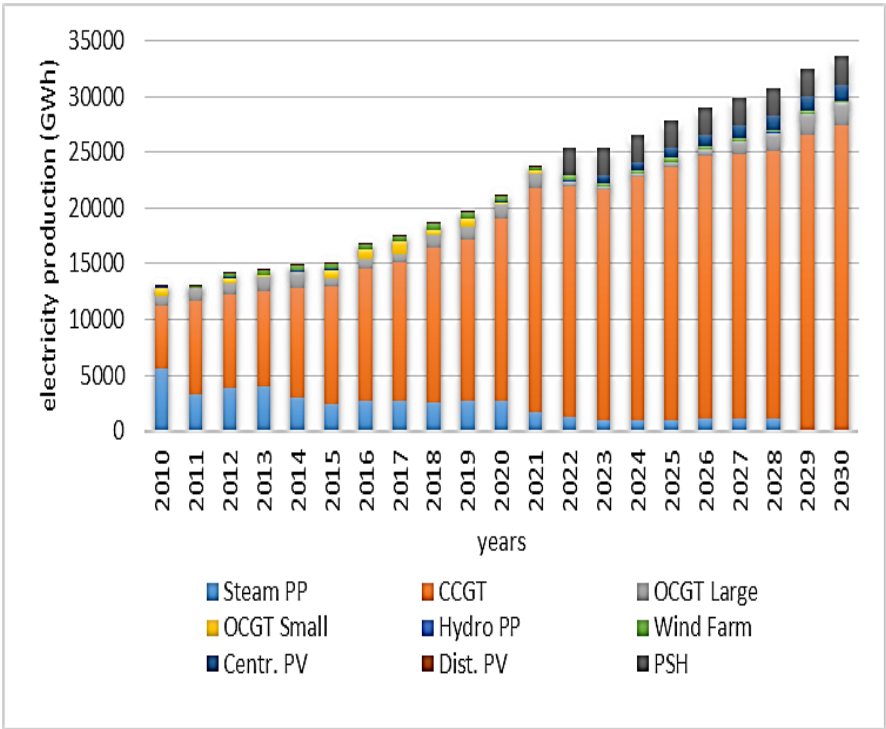
# Main Resulsts

## Discounted Costs

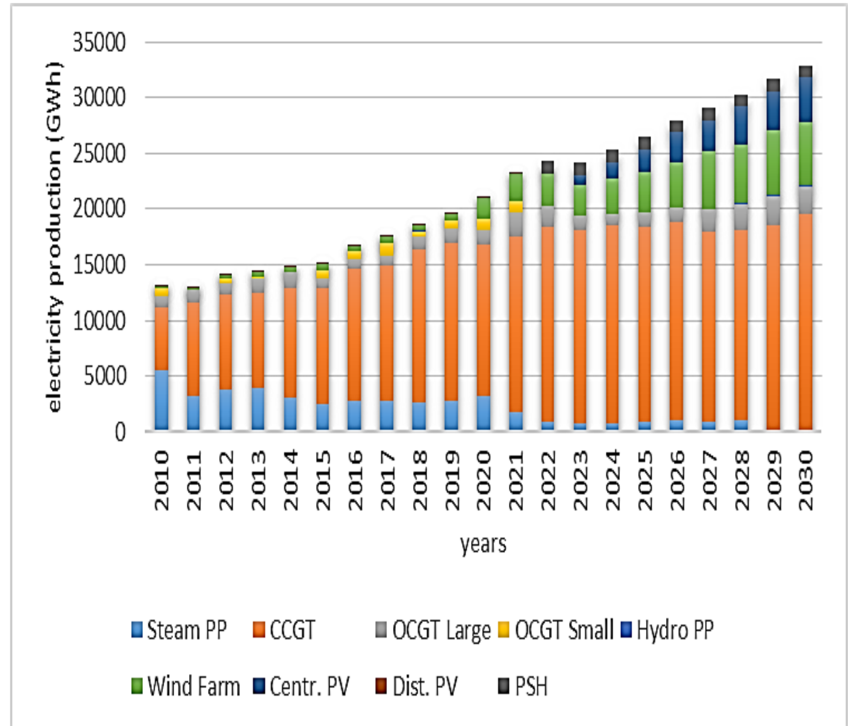


# Main Resulsts

## Electricity Mix



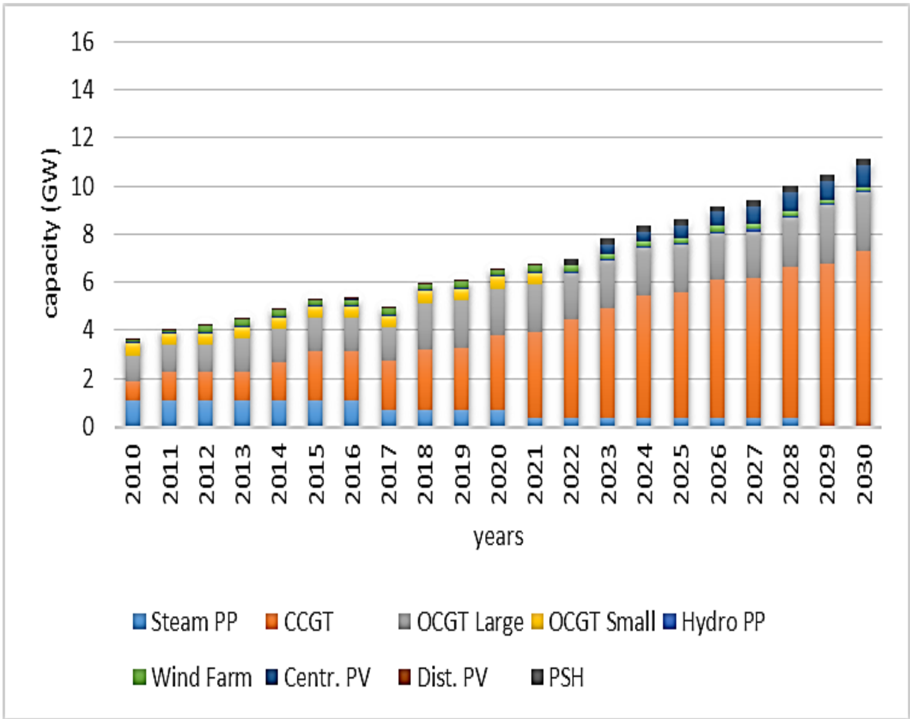

BAU Scenario



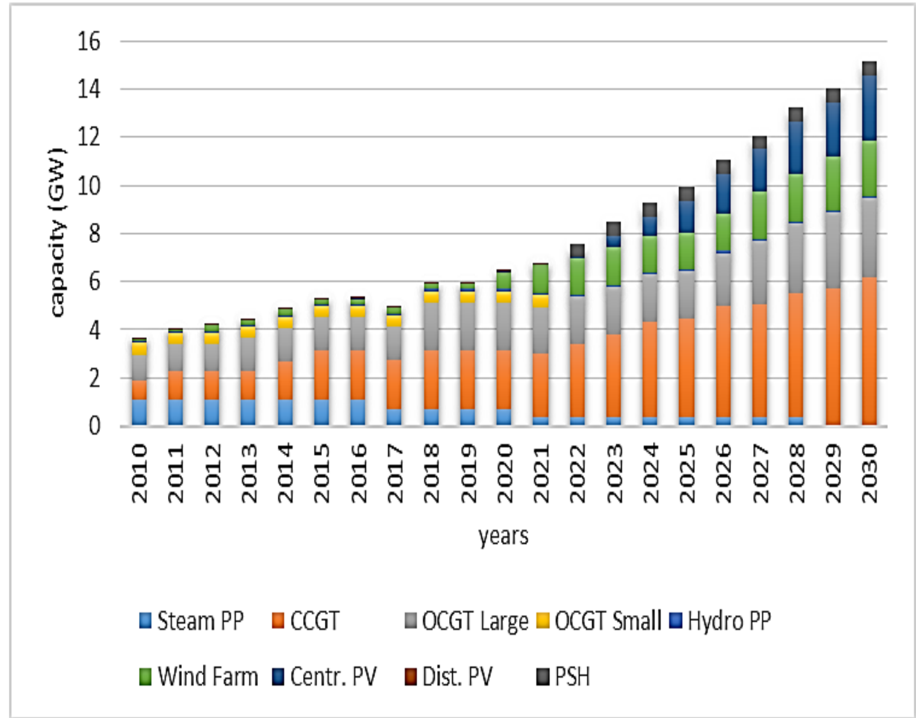

RE Scenario

# Main Resulsts

## Capacities Shares

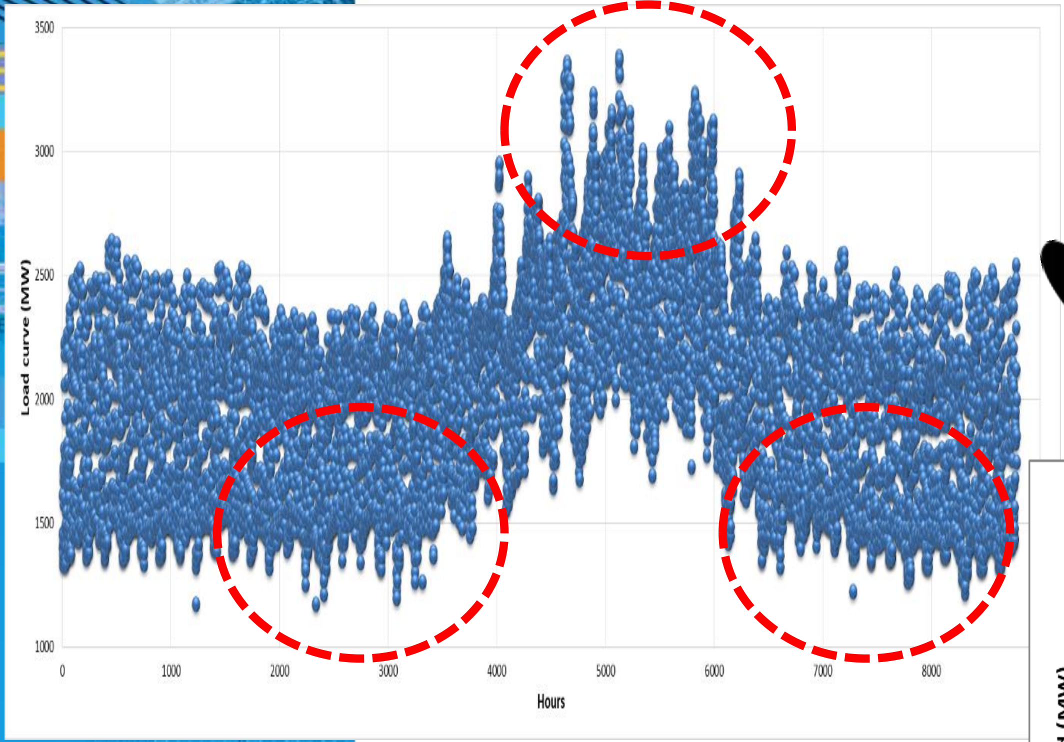



BAU Scenario

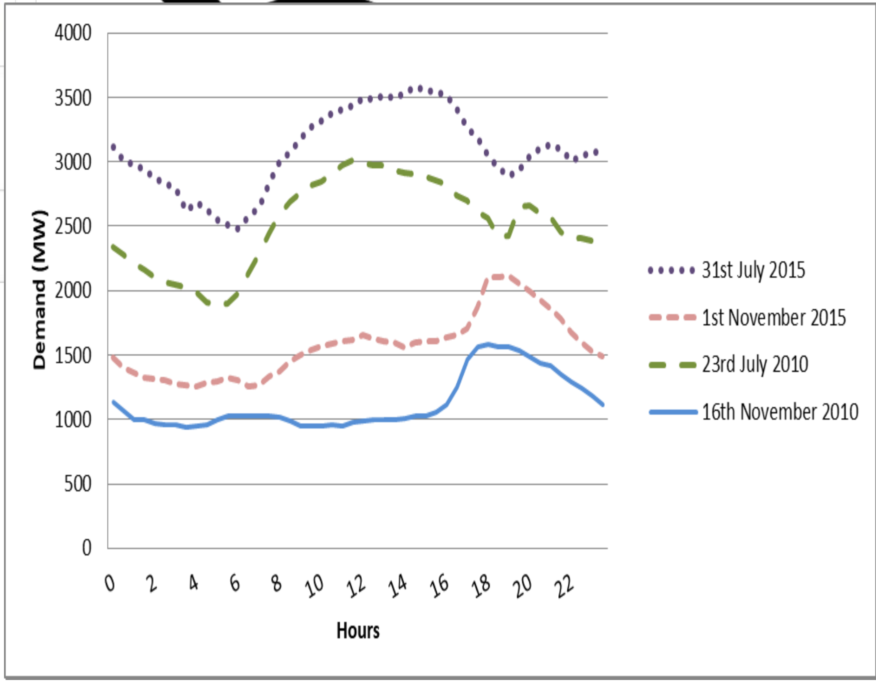



RE Scenario

# Main Resulsts




Annual load curve in 2016




Evolution of daily profiles

# Main Resulsts

## Impact of Energy Efficiency

Amongst energy efficiency actions:

- ➢Peak clipping: reducing the demand during peak periods through scheduled outages ☺
- ➢Load shedding: cutting electricity supply by zone during a period to manage the demand and avoid blackouts, due to the incremental peak or variability of RES ☹

➔ Load shedding could be associated to peak clipping, if it is targeted, well planned, and programmed in advance

- Peak clipping : decreasing the peak + avoiding the system operator from using costly technologies, low efficiency and polluting technologies

System reliability

# Main Resulsts

## Impact of Energy Efficiency

- System reliability: the rate of the satisfaction of demand of all customers
- System reliability could be associated to the Loss-of-Load Probability (LOLP)

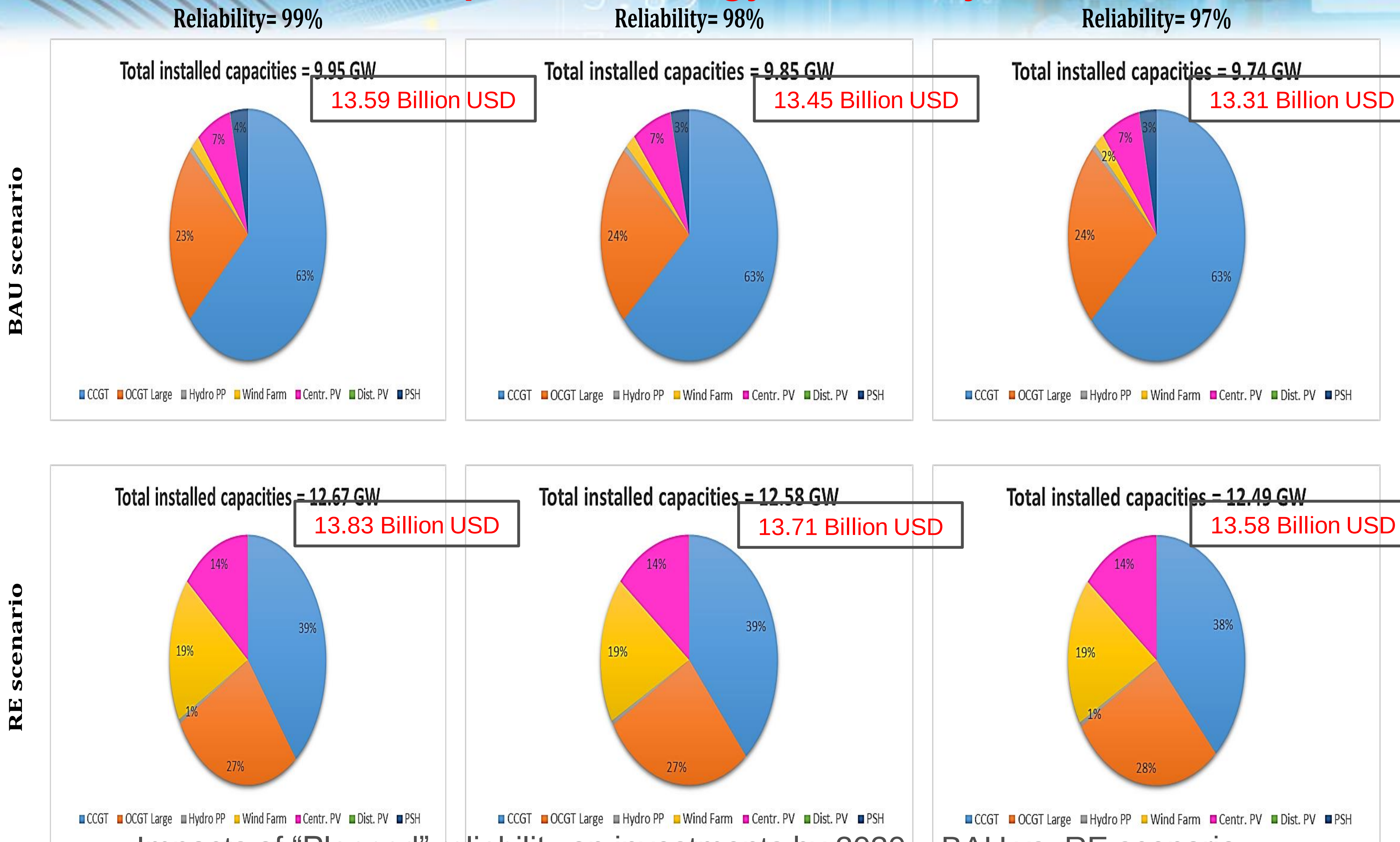
$$\forall_{r,l,f,y} \mathrm{SystemReliability}_{r,f,y} = \Pr(S \geq D) \text{ or } \mathrm{SystemReliability}_{r,f,y} = 1 - \mathrm{LOLP}_{r,f,y}$$

$$\forall_{r,l,f,y} production_{r,l,f,y} \geq demand_{r,l,f,y} + use_{r,l,f,y}$$

$$\forall_{r,l,f,y} \mathrm{production}_{r,l,f,y} \geq \mathrm{demand}_{r,l,f,y} \times (\mathrm{SystemReliability}_{r,f,y}) + \mathrm{use}_{r,l,f,y}$$

# Main Resulsts

## Impact of Energy Efficiency




Impacts of “Planned” reliability on investments by 2030 – BAU vs. RE scenario


# Conclusions

• The decrease of the reliability of the power system by 1% has allowed decreasing the costs of RE scenario by 0.12 billion 2010 USD and the costs of the BAU by 0.14 billion 2010 USD;
• The total cost of RE scenario at a reliability of 97% is equal to the cost of the BAU scenario at 99%, i.e. 13.58 billion 2010 USD. Achieving 30% of RE in the electricity mix with 97% of power system reliability is as costly as a BAU scenario with 99% reliability.
• The 2% decrease in system reliability while integrating RE could be assessed through EE actions such as peak clipping.

➢Decreasing system reliability could be seen as an energy efficiency action boosting the implementation of RES in the power system.
➢Such actions could be integrated alongside RE Government's objectives through outages tariffs or smart meters, etc.

# Thank you for your attention

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