Wind-based Combined Electricity and Clean Water Production for Remote Islands

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Scope and Objectives of the Work

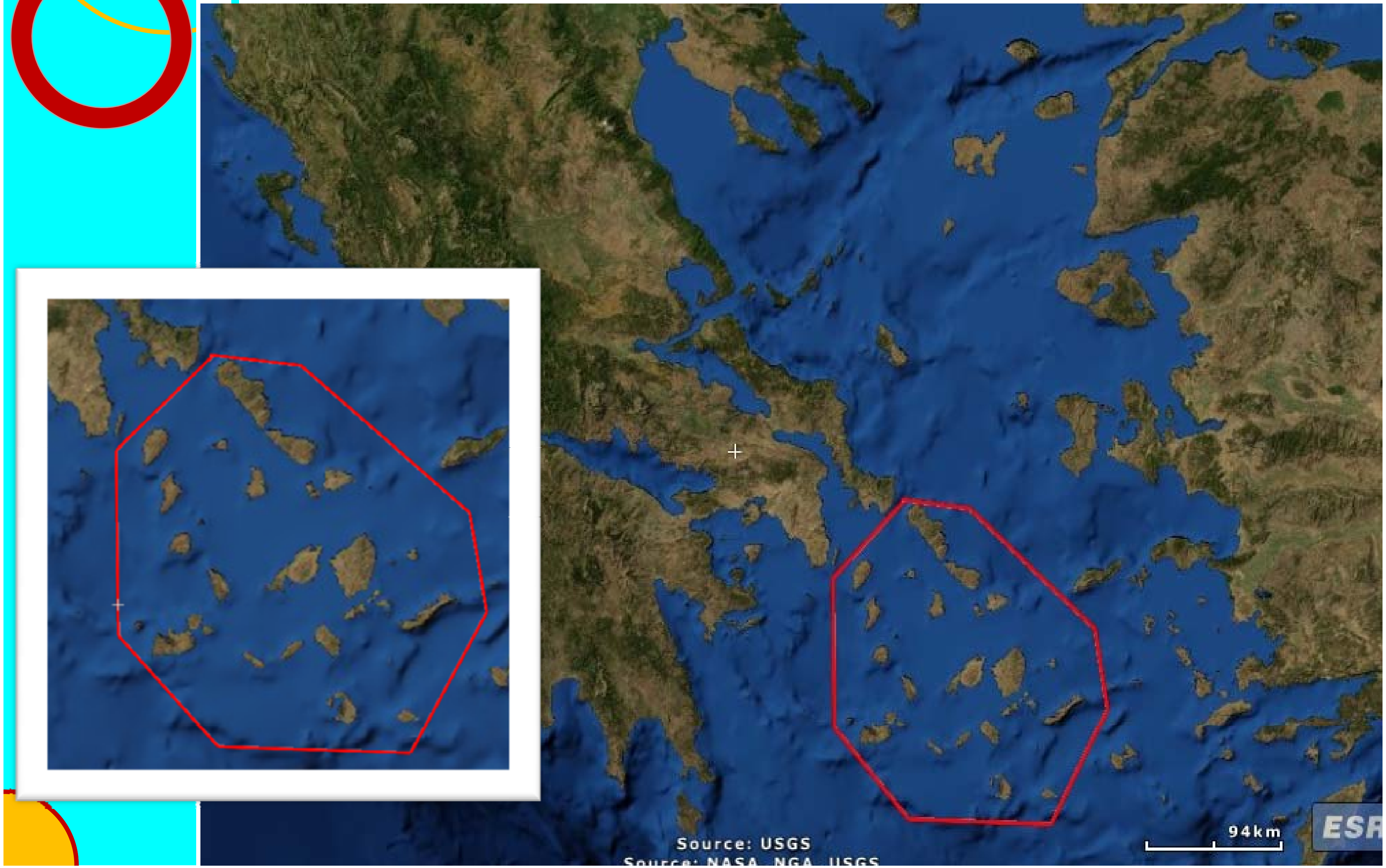
➢To investigate the opportunities for integrated electricity and clean water production on the basis of the wind potential of the Greek islands that face serious water and electricity shortages.

Rationale and Background of the problem

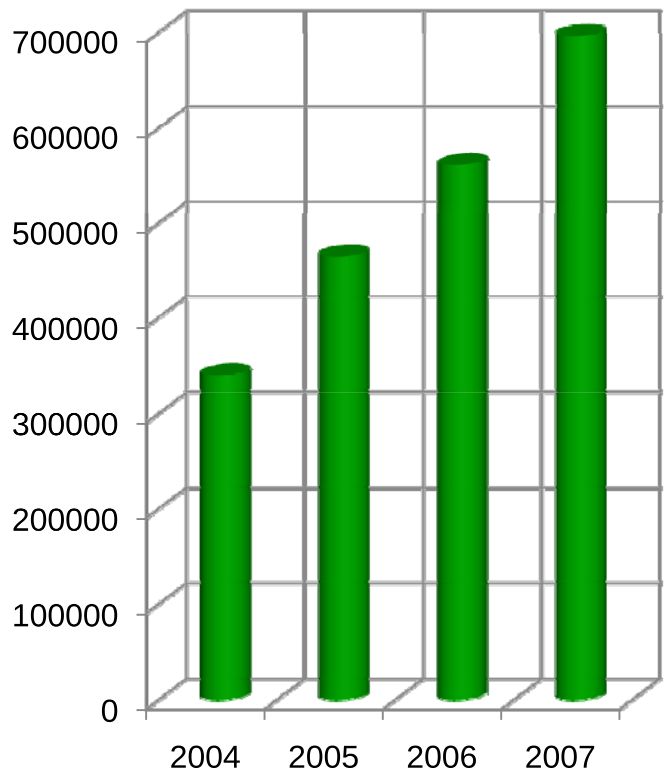
➢ *The European area most affected by water shortage seems to be the Mediterranean region.*

➢*Electrical Energy and clean water shortage are two of the most severe problems on non-interconnected islands of the Mediterranean sea (e.g. Aegean islands)*

A Map of the Aegean islands



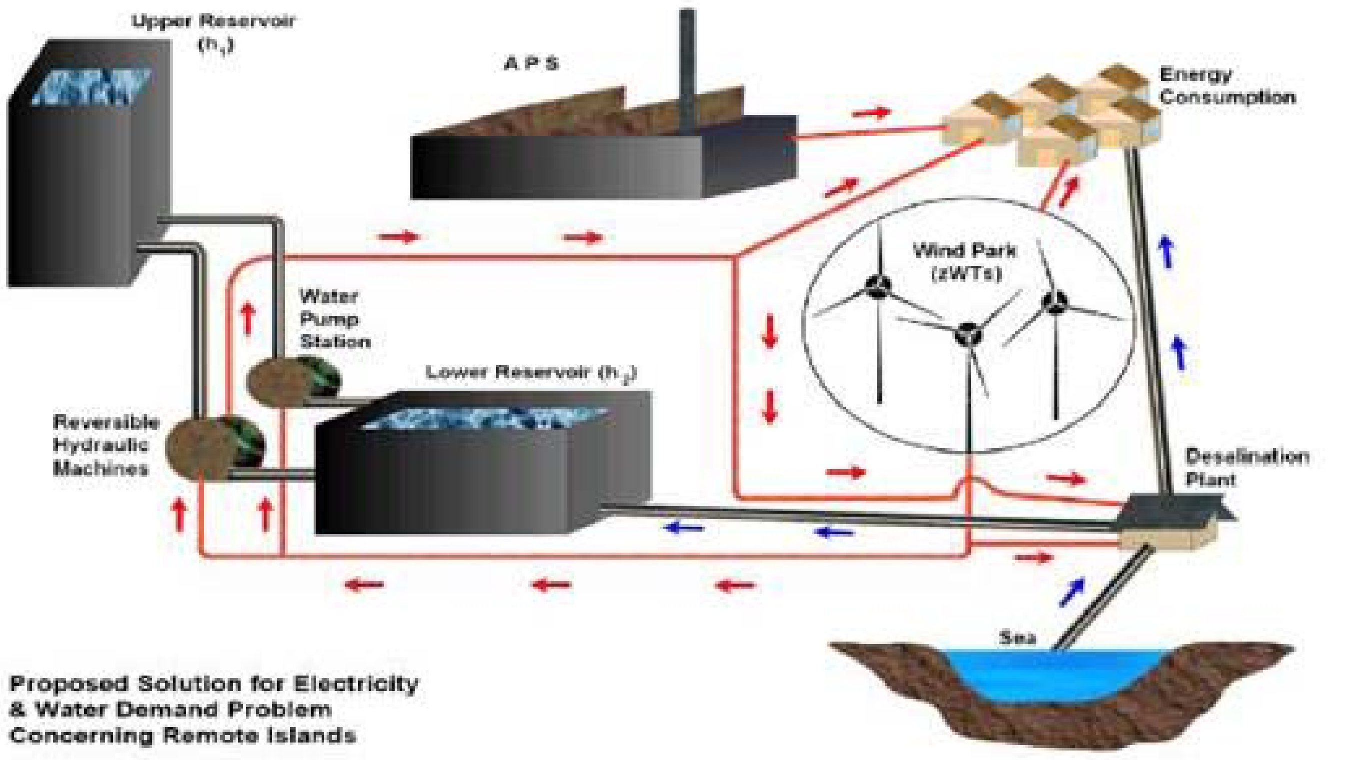
Problem characteristics



- In many islands water is transported at very high cost (reaching 10€/m^3).
- The Aegean islands have excellent wind potential.
- Therefore, the possibility to develop a combined wind based electrical power station in collaboration with an appropriate energy storage installation and a desalination plant is investigated.

Proposed Wind Based Solution

The most suitable configuration for covering both electrical energy and clean water demand



Configuration of the proposed solution

- One or more wind parks
- An appropriate energy storage installation (characterised by the days of energy autonomy)
- An electricity absorption system
- An electricity generation device
- A properly sized desalination plant
- A fresh water storage reservoir
- The existing APS

Alternative system status:

- The wind park supplies the local network and the desalination plant. Any surplus is directed to the desalination plant or water pumping system
- The wind energy production is lower thatn the demand. Energy and water stored quantities are exploited
- Water reserves are very low. Part of the wind energy is directed towards the desalination plant. The existing APS may be used.
- ....(other possible combinations.)

A challenging optimisation/planning problem

- In order to optimise the overall operation of the integrated system, a tool for its planning is required.
- This planning tool will indicate the time periods that the system will produce and store power, will produce and store water or both.
- The planning criteria in a real system will change continuously depending on the priorities being set.
- Therefore, there is a wide scope for optimisation.

Case study

➢ The developed methodology has been applied to a representative medium-small scale Aegean island of 1000 inhabitants.

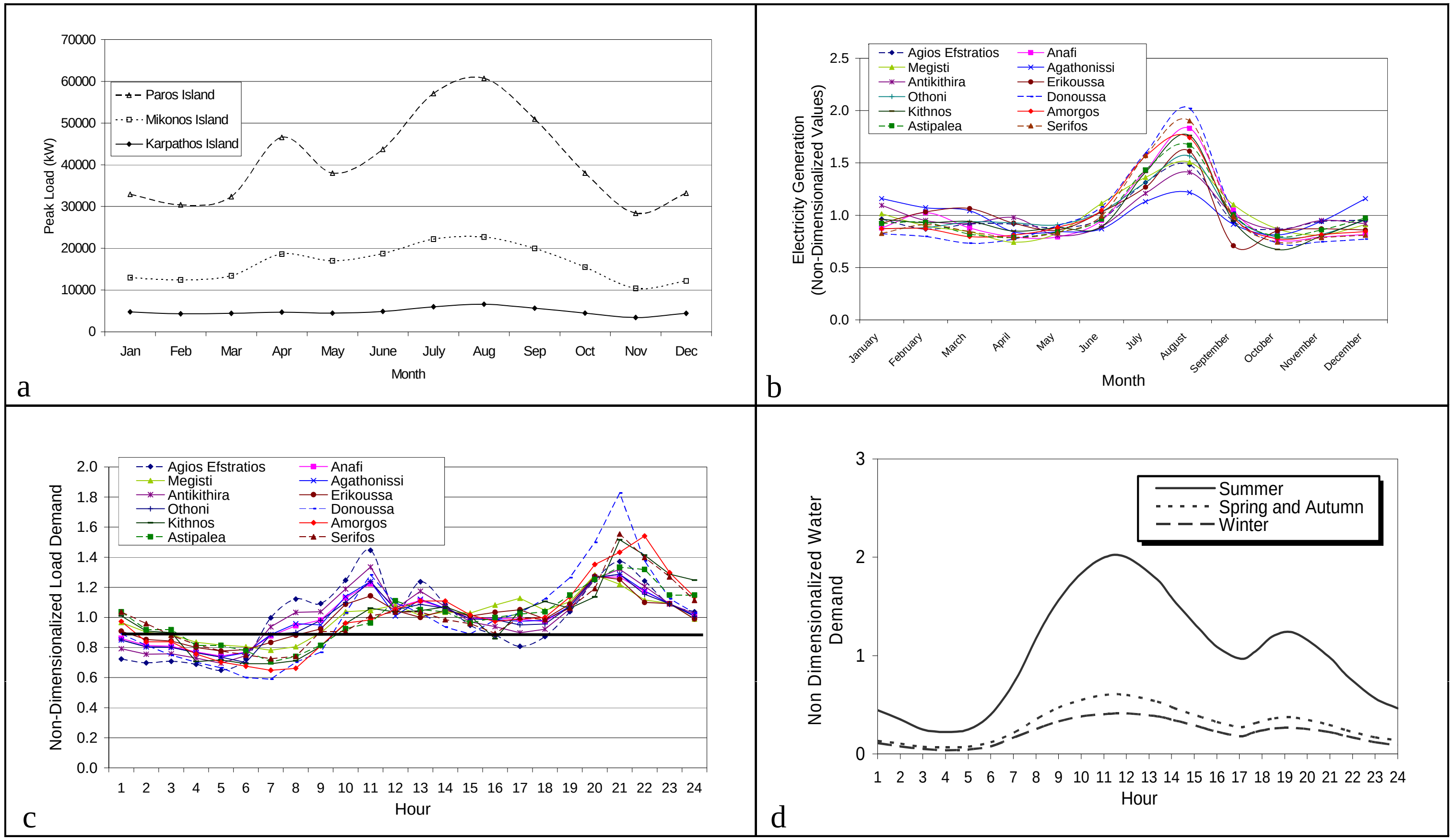
- *Annual electricity generation: 6GWh$_e$*
- *Peak load demand: 4.5MW$_e$*
- *Rated power of the local APS : 5MW$_e$.*
- *Annual water consumption 80,000m^3.*

The proposed algorithm is configured such as:

➢ *full coverage of potable water needs is achieved in combination with*

➢ *the minimization of fuel imports*

Profile of power and water demand

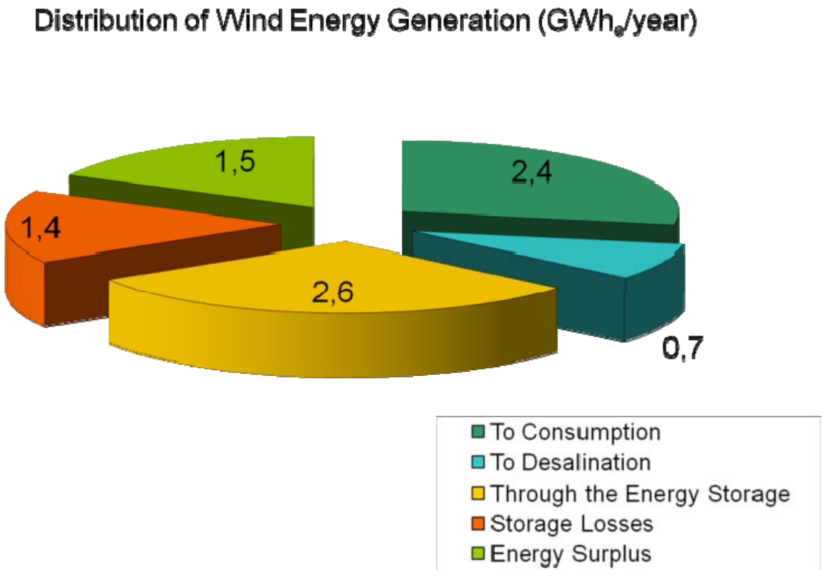


Results

➢According to the results obtained, complete satisfaction of the island electricity needs may be undertaken by the operation of a

➢**N^*_w=4MW wind park,** which by exploiting the local wind energy potential **(CF=25.2%)** may deliver to the local consumption

➢annual energy yield of **8.6GWh$_e$,** distributed on the basis of results presented in the following Figure.



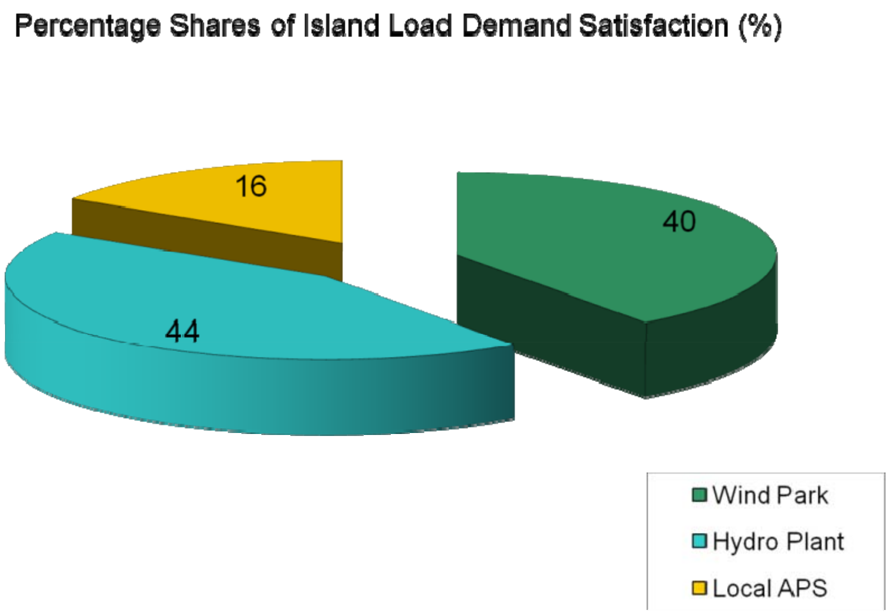
Results

➢Actually, operation of the wind park implies 40% direct coverage of the island’s energy needs,

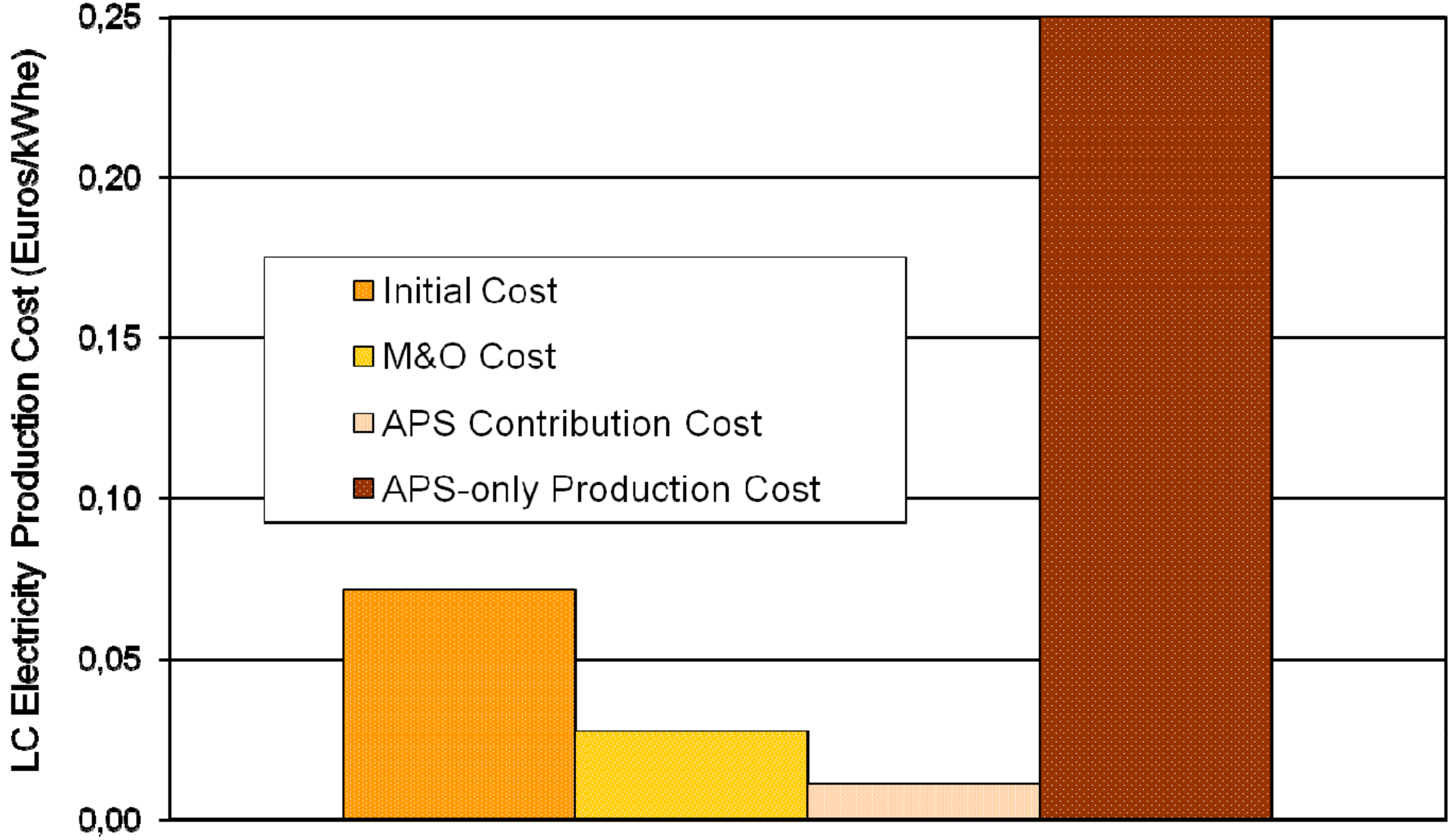
➢While 0.7GWh$_e$ are directly absorbed by the desalination unit.

➢ Furthermore, 2.6GWh$_e$ reach consumption through the energy storage system which also induces round trip energy losses of 1.4GWh$_e$.

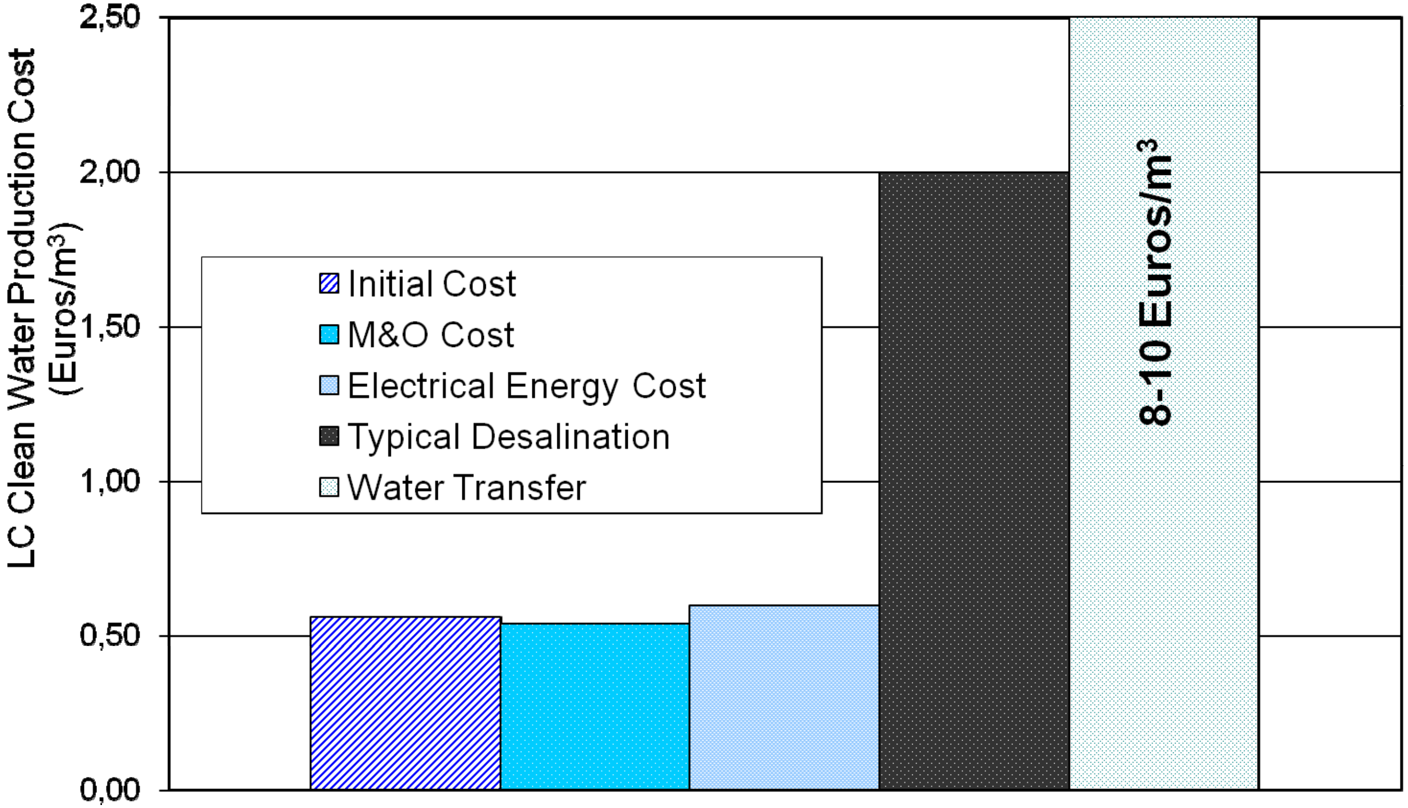
➢Load demand: 40% is directly covered by the operation of the wind park, while for the rest 60% contribution of the wind-hydro station is responsible for 44% leaving only 16% to the local APS.



Resulting electricity production cost



Clean water production cost



Unit's cost in numbers…

Electricity production cost: 0,11 €/Kwh (65% initial investment cost, 25% M&O cost, 10% local APS)

Clean water production cost 1,7 €/m3 (0,56 initial investment cost, 0,54 M&O cost, 0,6 electrical energy cost)

Conclusions

- The work investigates the combined electricity and clean water production opportunities on the basis of the available wind potential.

- Maximisation of a properly defined value is attempted.

- The wind energy is directed to the electrical network and/or a desalination plant for fresh water production.

- Resulting costs are very favourably compared to other solutions.

- The work is ongoing attempting to develop the proper generic mathematical model and solve for various case studies.