Desalination Units powered by Renewable Energy Systems,
Opportunities and Challlenges
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Using geothermal and solar energy for autonomous water desalination units

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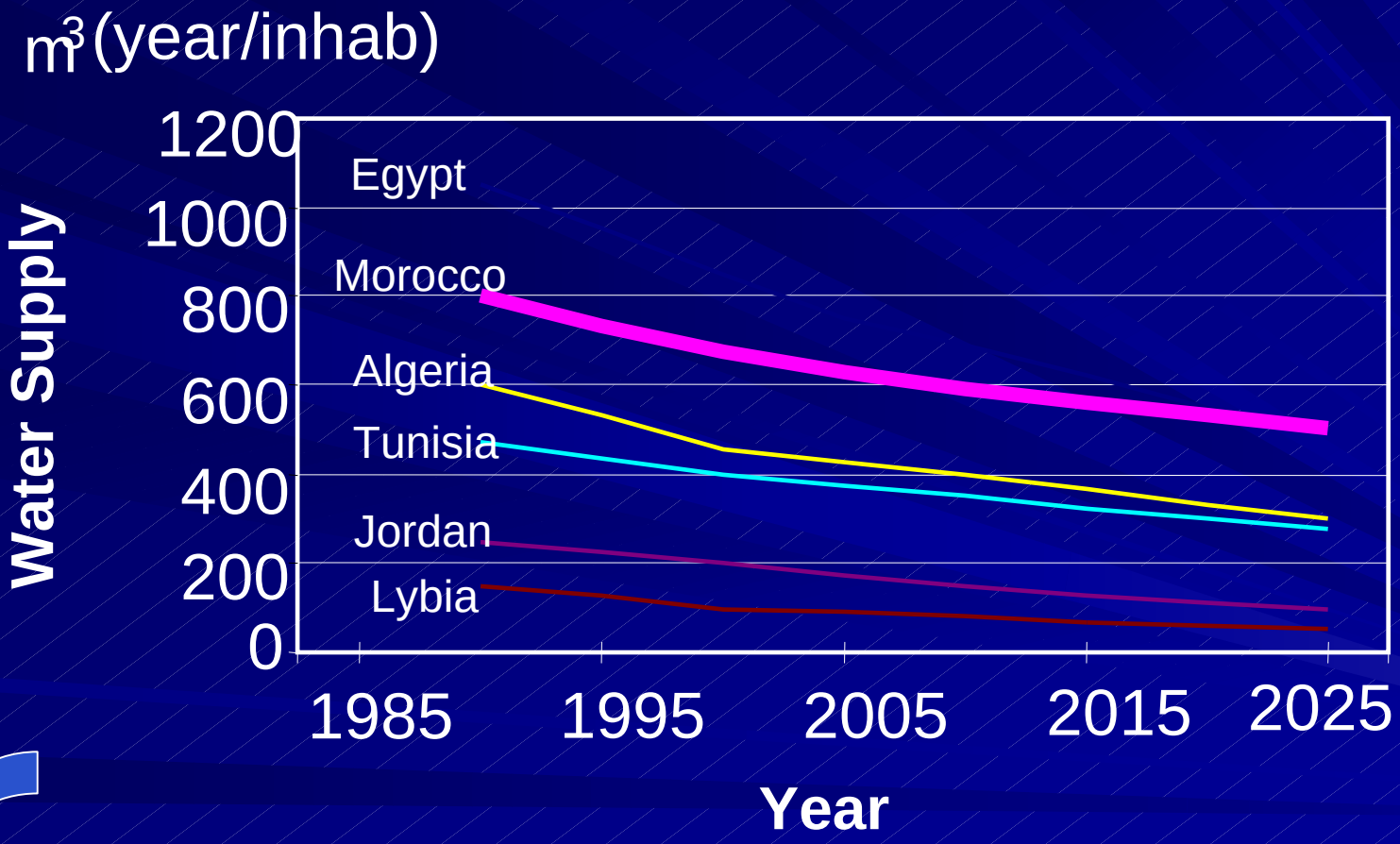
Plan of the presentation

- Problematic
- Water consumption and resources in Tunisia
- Energy consumption and resources in Tunisia
- Desalination by renewable energy
- Geothermal energy in Tunisia
- Brackish water desalination by geothermal and solar energy in Tunisia
- Conclusion

Problematic :

Water Supply situation in Mediterranean countries

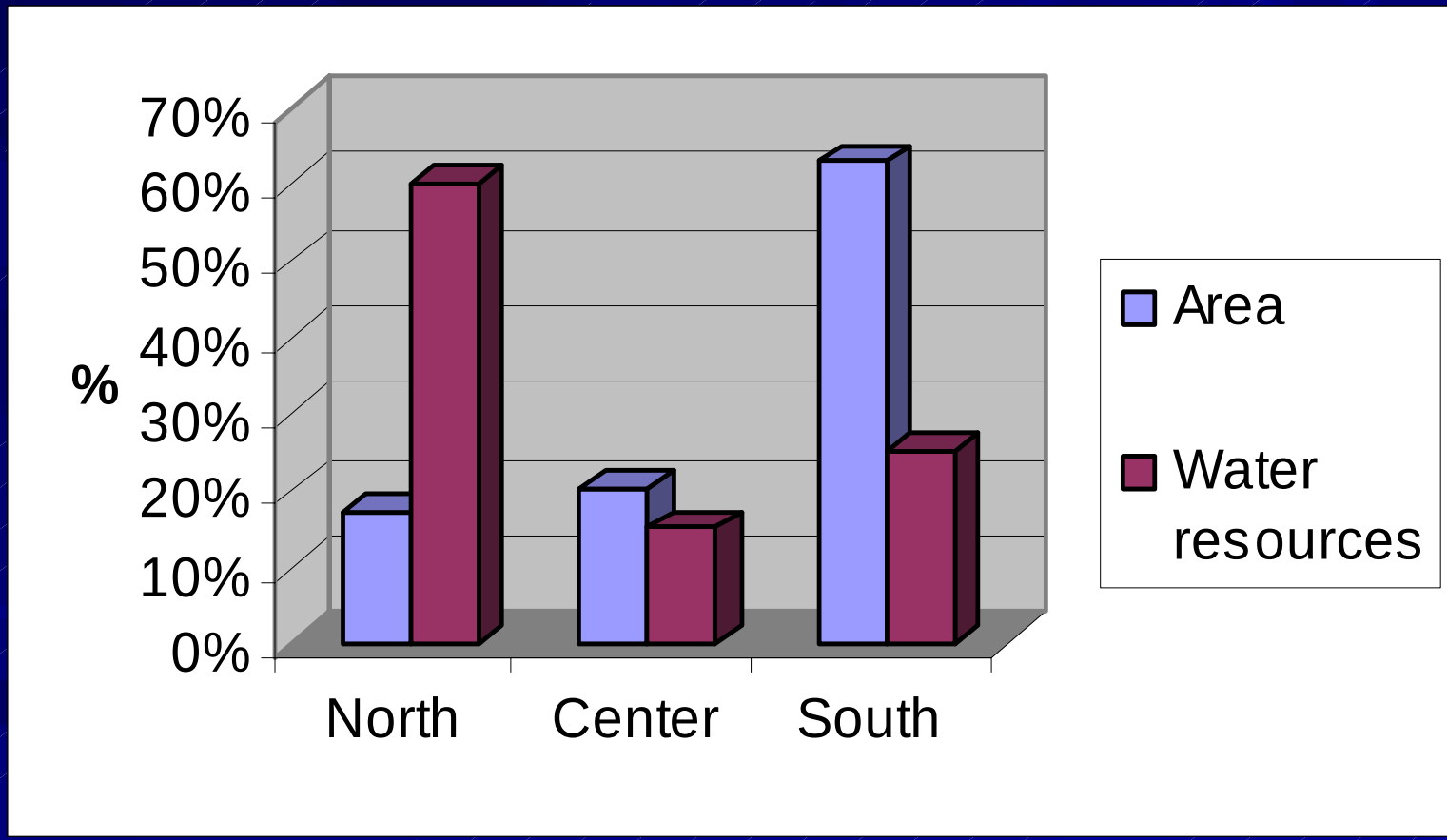


Tunisia is one of the most concerned Mediterranean countries by water deficiency

Problematic

- ✓ Arid and semi-arid climate in Tunisia
- ✓ The available water resources are rather modest in terms of both quantity and quality
- ✓ The global potential of water resources in the country amounts to 4545 Mm^3/year :
  - ✓ 1845 Mm^3 ground water
  - ✓ 2700 Mm^3 Surface water

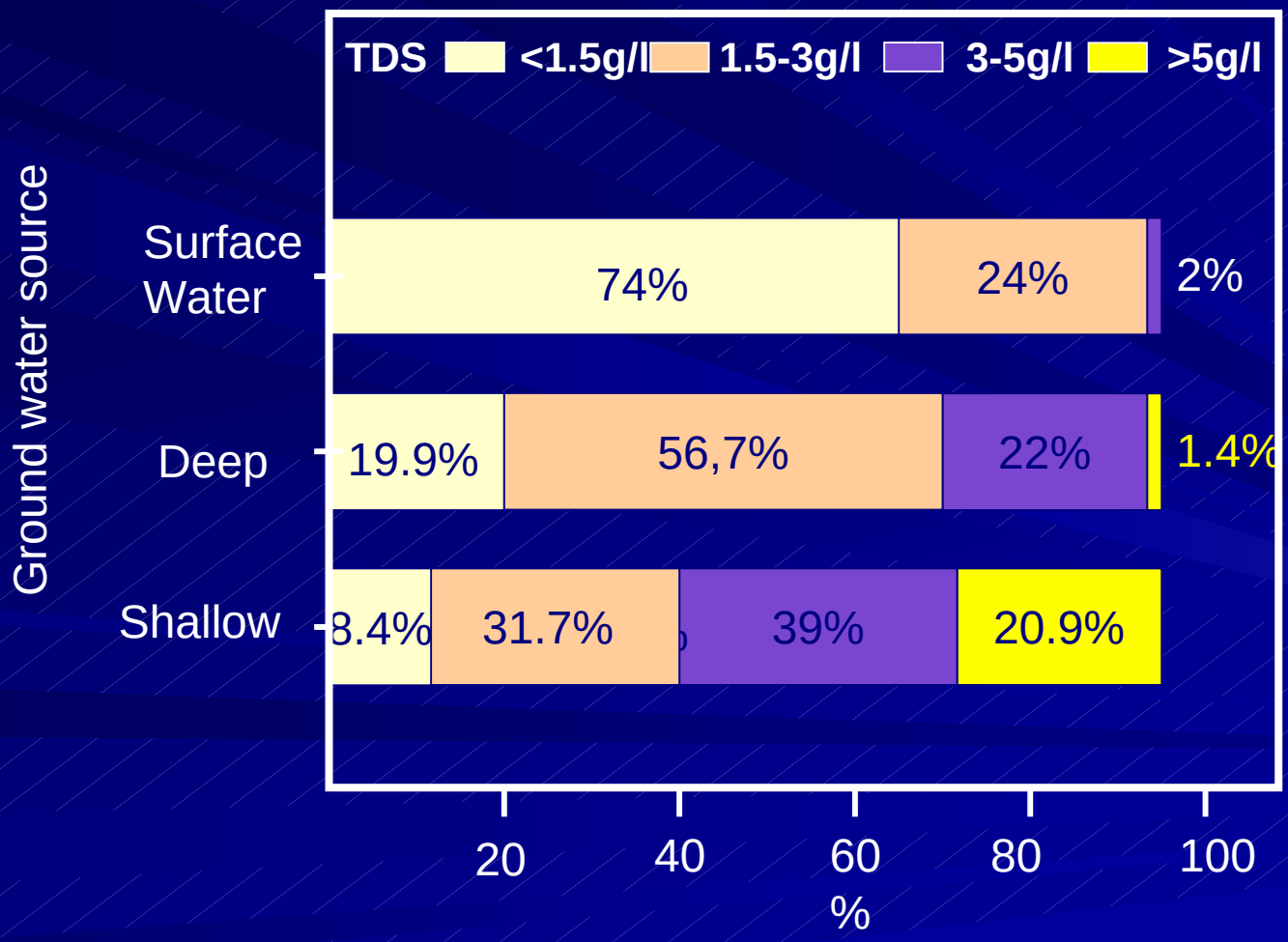
Regional Distribution of potential water resources in Tunisia



Water Resources availability by region

	Region (Area%)			
	Northern (17)	Central (22)	Southern (61)	Total (100)
Surface Water Mm^3/y	2185	290	225	2700
Ground Water Mm^3/y	550	465	830	1845
Total Water resources Mm^3/y	2735	755	1055	4545
Total over all regions, %	60	17	23	100

Water resources classification according to salinity levels



Water quality problem

Large percentage of these waters need to be desalted before they can be exploited

Modest water Resources potential

Poor quality of Most of its groundwater resources

Tunisia must find new sources of water

Importance of Agriculture for Tunisian economy

The solution

In order to :

- cover for any future deficit in water
- improve the quality of water

Desalination = Adequate solution

Currently, desalination is practiced in Tunisia on a small scale (The installed capacity = 70.000 m^3/d, Reverse Osmosis) :

South : Gabes, Islands of Jerba and Kerkenah

Evolution of water needs

Basing on :

– Statistics on water resources availability

– Water demand figures

☞ Desalination is expected to be carried out on a wider scale in the near future

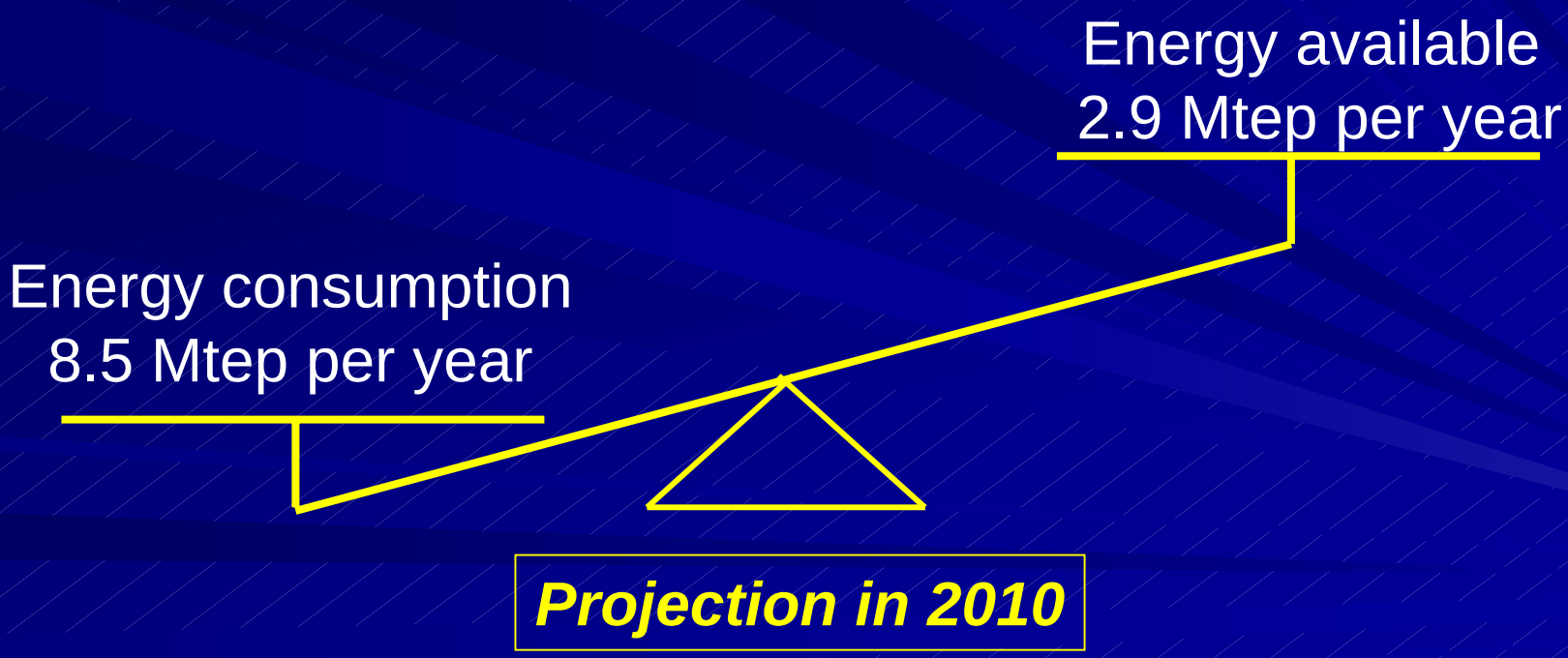
- All the installed desalination plants function by conventional energy

Energy demand projections in Tunisia (in Mtep)

	Year		
	1998	2001	2010
Oil products	3,48	3,90	5,60
Natural gas	0,51	0,62	1,30
Electricity	0,60	0,80	1,40
Coke	0,06	0,08	0,10
Solar	---	---	0,10
Total	4,65	5,40	8,50

Desalination and energy

Tunisia has not important energy sources



Using Renewable Energy

Depletion of its fossil energy sources

Environmental problem

Tunisia looks for the answer of water and energy scarcity problem in the use of its abundant and readily available renewable energy sources as a cleaner and safer way for providing water (Solar, Wind and geothermal energy).

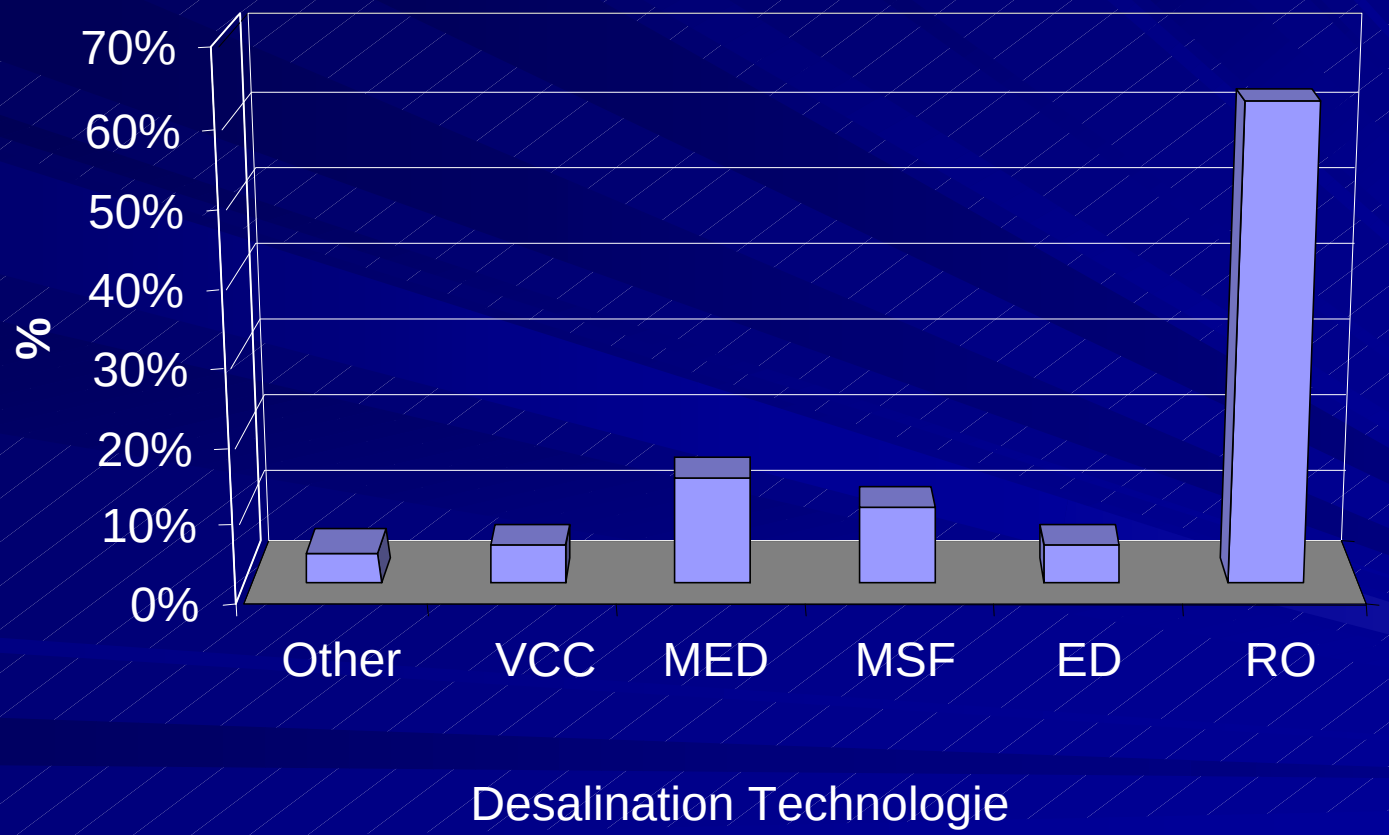
Desalination and Renewable Energy

- Desalination by means of renewable energy sources is a suitable solution for providing water to a number of regions in Tunisia and in the Mediterranean Basin in general.
- This solution becomes more and more competitive especially for remote and rural areas where small quantities of water are needed.
- Nowaday, and given the advanced in desalination technologies, small-and medium-size desalination units can be easily designed

Plausible Coupling combination between renewable energy and desalting technologies

Renewable energy sources		Desalting technologies					
		RO	ED	ME	TVC	MVC	MSF
Solar	Solar thermal			✓	✓	✓	✓
	Solar photovoltaic	✓	✓			✓	
Wind	Wind shaft	✓				✓	✓
	Wind electric	✓	✓			✓	
Geothermal	Geothermal heat			✓	✓	✓	✓
	Geothermal electric	✓	✓			✓	

Desalination and renewable energies



Geothermal energy coupling

- The Energy output is generally invariant with less intermittence problems making them ideal for thermal desalination process.
- Most of the geothermal sources in the country are of low enthalpy class (maximum temperatures 70-90°C)
- The Cooling systems used for irrigation with geothermal water can function also as desalination units

Geothermal sources in Tunisia

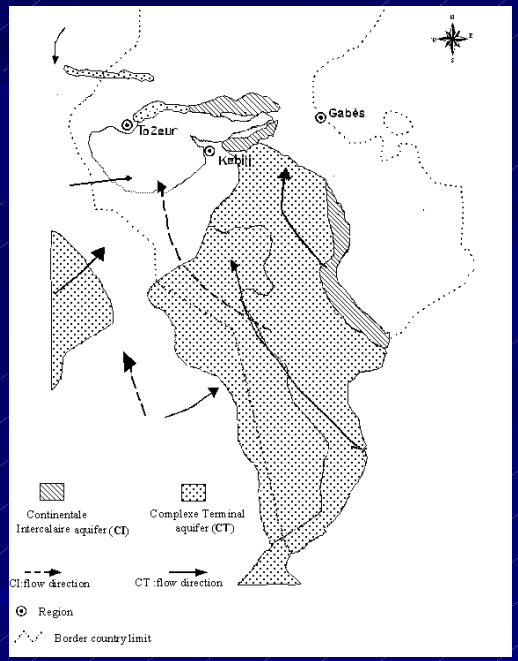
- Most geothermal sources in Tunisia have low enthalpy with maximum temperatures of 70-90°C.

- South Tunisia can be divided into the following major geothermal aquifers:

  – The Continental Intercalaire, CI., extended on an area of 600.000 km2 in the whole region of Algeria, Libya and Tunisia. The small part localized in Tunisia is distinguished by an aquifer (more than 1000 m of depth) with high pressure (10 bars), temperature reaching 70°C and with TDS range from 2.5 to 5g/l.

  – The Complex Terminal CT., with geothermal aquifers in Nefzaoua and El Djerid. The reservoir has an extension of about 350.000 km^2 in which a small area is located in Tunisia. Its temperature range from 30-50°C (100-600 m of depth). The total dissolved solids (TDS) range from 1.5 to 8g/l.

Geothermal ressources in the south of Tunisia



Geothermal water resources in the south of Tunisia

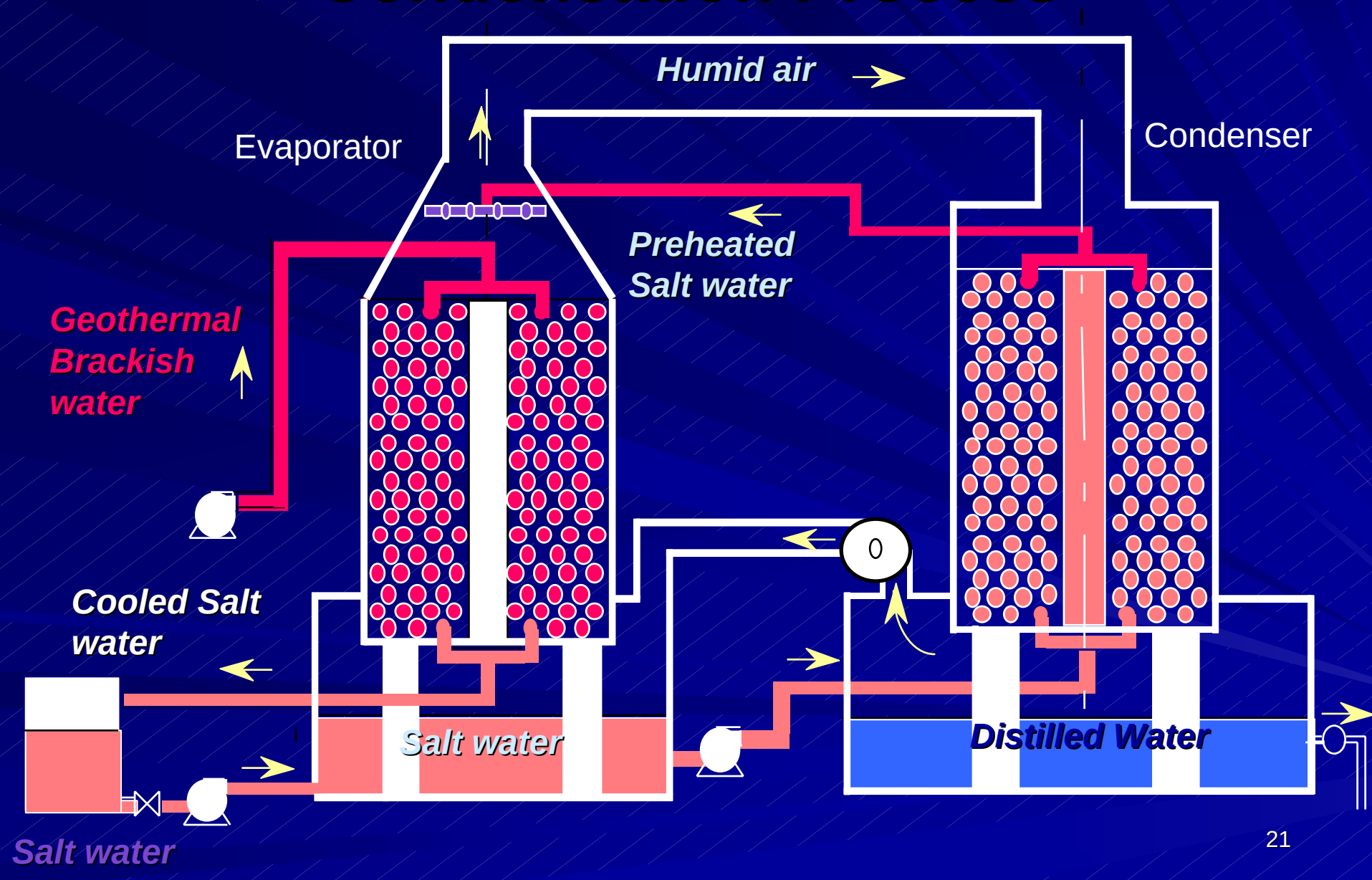
Aquifers	Total resources	With drawal	Aquifers exploitation (%)
CT	352.300	460.870	131%
CI	82.360	72.010	87%
Djeffara	115.110	102.88	89%
Total	549.770	635.760	116 %

Potential and exploitation of geothermal water aquifers in south Tunisian in Mm3/year

A process for brackish water desalination for rural regions

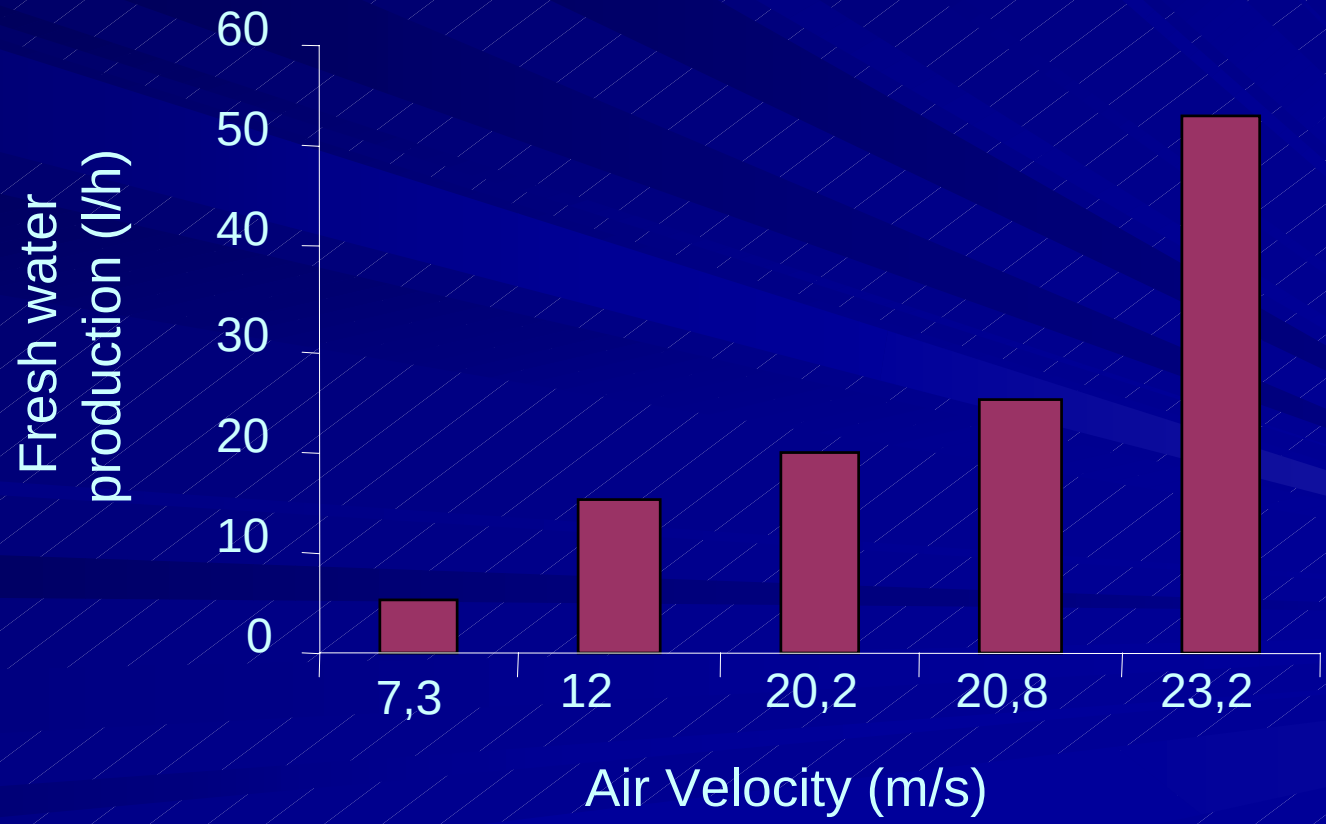
- The population in the south-west of Tunisia is dispersed (water needs are limited)
- The agriculture represents the most important activity (Oasis)
- In these regions water resources are not important and conventional energy resources are not available
- Water resources are often brackish and geothermal
- The Common desalination processes are not adequate

Desalination by Aero-Evapo-Condensation Process



Expermiental results

- Promising results with geothermal springs
- Determination of the governing parameters (Air velocity, humidity, inlet temperature, etc.)



Constrains

- The condensation at high temperature
- Wettability of the tubes
- Distribution of the liquid film flow
- Geothermal energy is not present in all emplacements

Work in progress

- Solar coupling

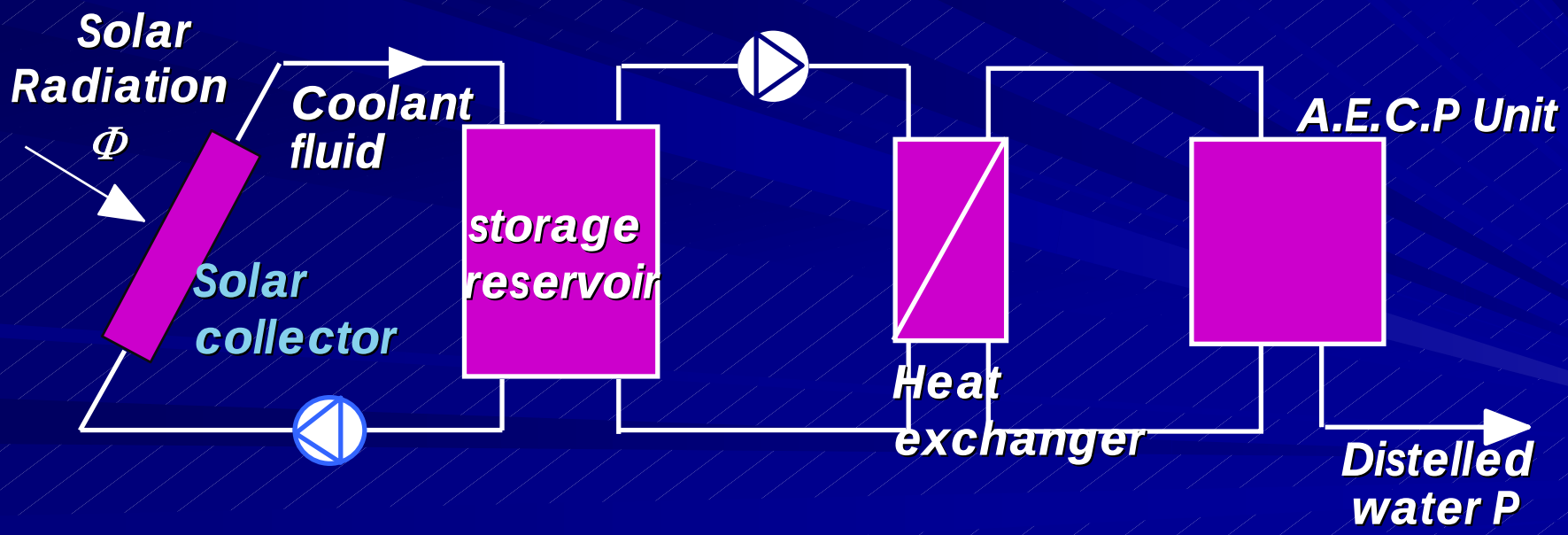
  Simulation of coupling the desalination unit to the solar collectors (several scenarios) basing on the weather data of Tunis for 2000

- Condensation problems (SERST Project)

  Development of a study on film condensation outside horizontal tubes

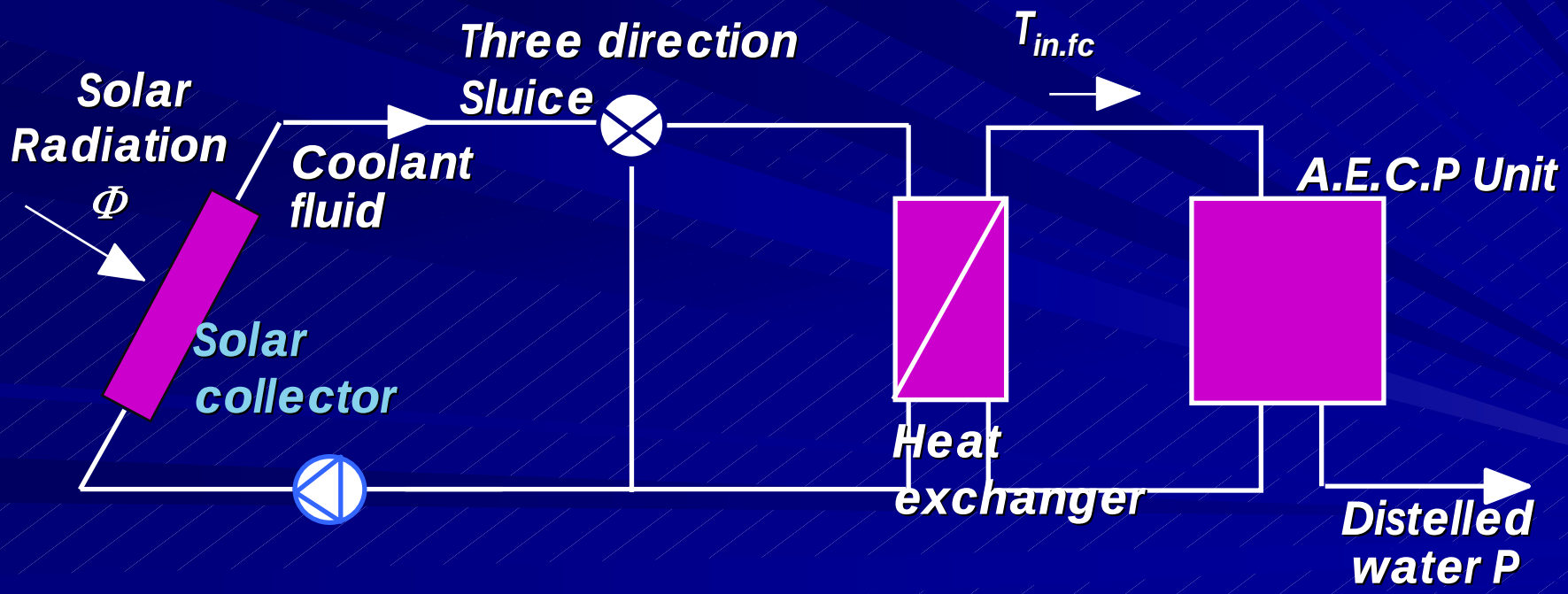
Coupling A.E.C.P Unit–Solar Collectors

First Scenario :



Coupling A.E.C.P Unit–Solar Collectors

Second Scenario :



Comparison of The water cost for different kinds of energy

Process	***The cost of cubic meter of distilled water***
Aero-Evapo-Condensation Process coupled to Boiler (Fuel)	***4.8 $***
Aero-Evapo-Condensation Process coupled to Solar Collector	***1.58 $***
Aero-Evapo-Condensation Process coupled to Geothermal Spring	***1.2 $***

Conclusions

- The prospects of geothermal energy for water desalination in Tunisia could be interesting in the future

- The direct use in thermal desalination plants (MED, TVC) could still give promising results.

- The numerical results for coupling with solar collectors are encouraging

Perspectives and work in progress

- Investigation of other scenarios for solar energy coupling
- Experimentation with solar collectors
- Investigation on the condensation problems for other configurations
- Improvement in the design of the unit