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INTEGRATED WIND AND SOLAR QATTARA DEPRESSION PROJECT WITH PUMPED STORAGE AS PART OF DESERTEC

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ABSTRACT

A safe and economical approach is suggested to realize a wind and solar hydroelectric project at the Qattara Depression as part of the Desertec initiative. Instead of tunneling through the coastal hills as proposed in previous investigations, pipes can convey pumped water from the Mediterranean Sea to the upper Deir Kourayim reservoir and down to the depression. Wind turbines farms would provide the electricity to pump the water up into the reservoir. There, its potential energy is stored and then released to the Qattara Depression when electricity is in demand. While normal wind farms destabilize the frequency and voltage of the electrical grid due to the wind intermittency and sudden changes in wind speeds and thus varying power outputs, these wind turbines will not be connected to the grid but drive directly the pumps leading to the pumped energy storage reservoir. Not only can the intermittency of wind power be overcome and the produced electricity be constant for base-load application, but also an amount of energy corresponding to the difference in the ≥ 60 m elevation can be extracted.

An economical and technical analysis comparing the proposed approach to the previous tunneling one reveals the possibility of producing a larger amount of power of 1,120-1,550 MWe compared with 338 MWe. This is also associated with a more favorable capital cost of the electrical installed capacity at $3,560/kWe compared with 5,860 $/kWe.

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DESERTEC Concept

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Location of the Qattara Depression.

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Satellite picture of the Qattara Depression. Source: NASA.

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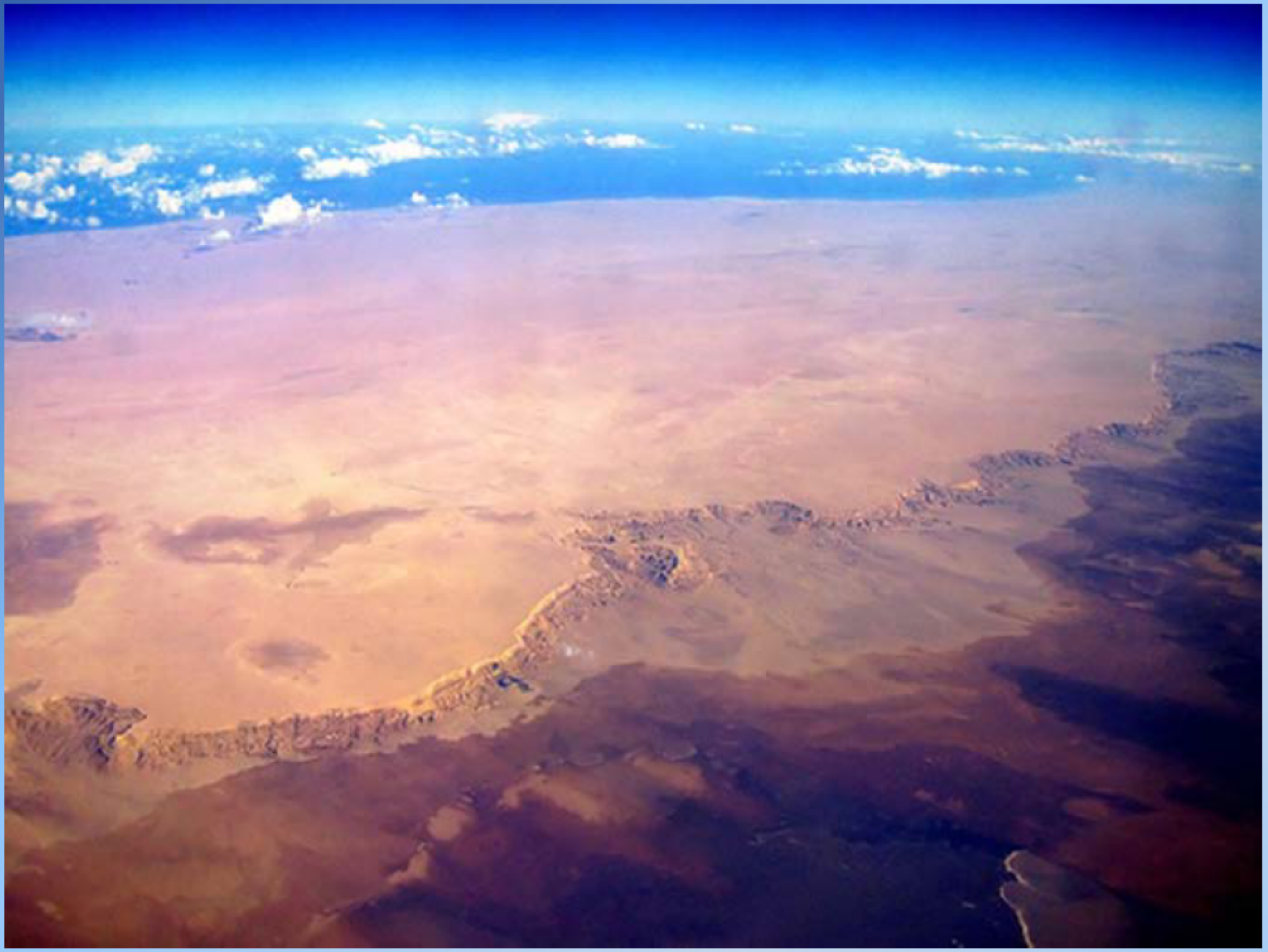
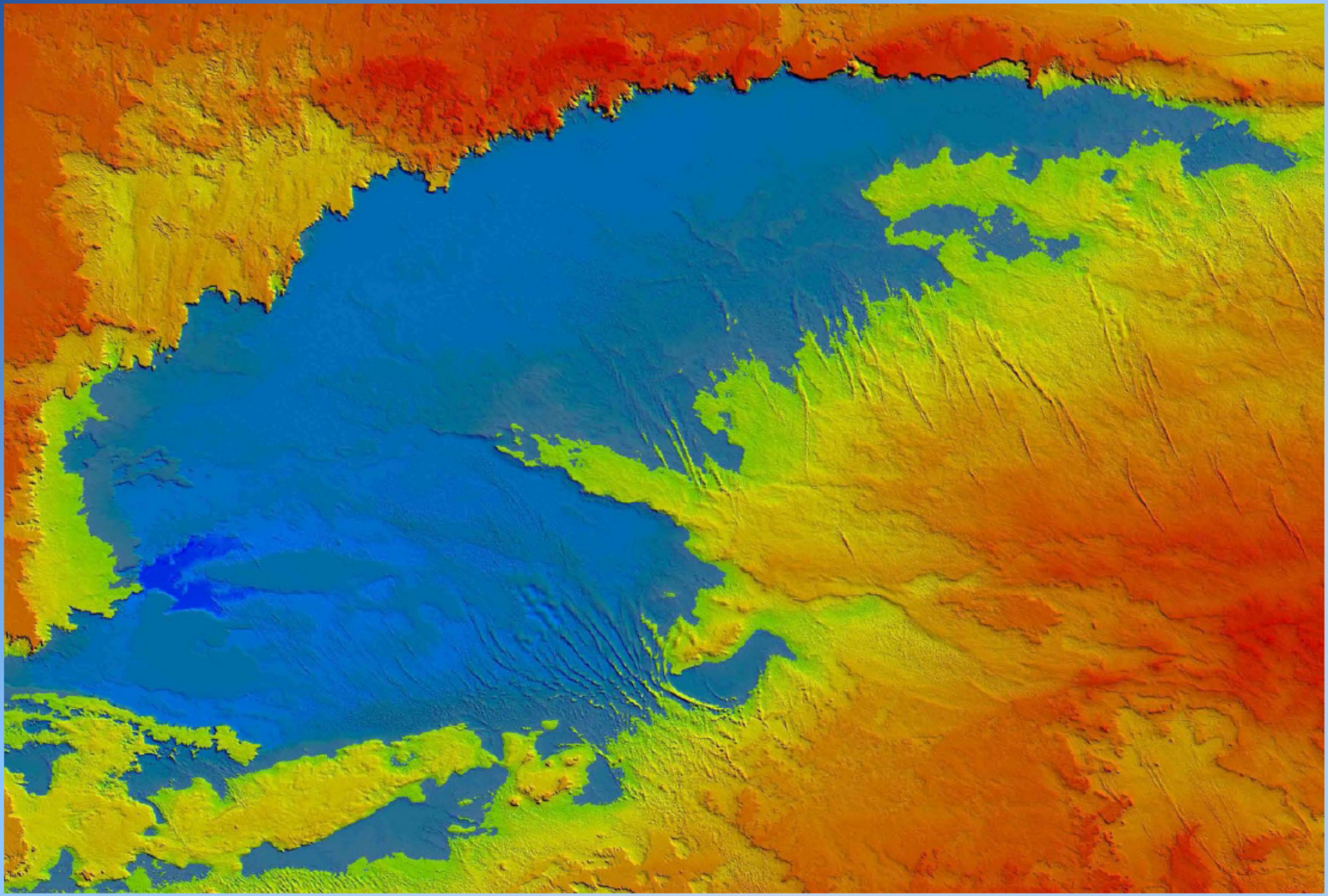
Aerial view of the Qattara Depression and the Mediterranean Sea in the distance.



Major world depressions.

Depression	Location	Elevation below mean sea level, msl [m]	Surface Area below Sea Level [km^2]	Distance from Sea or Ocean [km]
Dead Sea shore	Jordan/Israel	401-408	3,800	72
Near Lake Tiberias	Syria	200-212		50
Lake Assal shore	Djibouti	154-155	80	15
Turfan Pendi	China	154	5,000	1,500
Qattara Depression	Egypt	120-134	26,000-44,000	56
Vpadina Kaundy	Kazakhstan	132		
Denakil Depression	Ethiopia	125		
Laguna del Carbon	Argentina	105		
Death valley	USA	86		
Near Kulul within the Denakil Depression	Eritrea	75		
Sebkha Tah	Morocco	55		
Sebjet Tah	Western Sahara	55		
Sabkhat Ghuzayyil	Libya	47		
Lago Enriquillo	Dominican Republic	46		
Chott Melrhir	Algeria	40		
Caspian shore	Azerbaijan/Iran/Russia	28		
Shatt Al Gharsah	Tunisia	17		
Lake Eyre	Australia	15		
Sariqarnish Kuli	Uzbekistan	12		
Laguna Salada	Mexico	10		

Qattara Depression Digital Elevation Data (DEM) originating from the NASA Shuttle Radar Topographic Data Mission (SRTM) from data held at the National Map Seamless Data Distribution System. [1].



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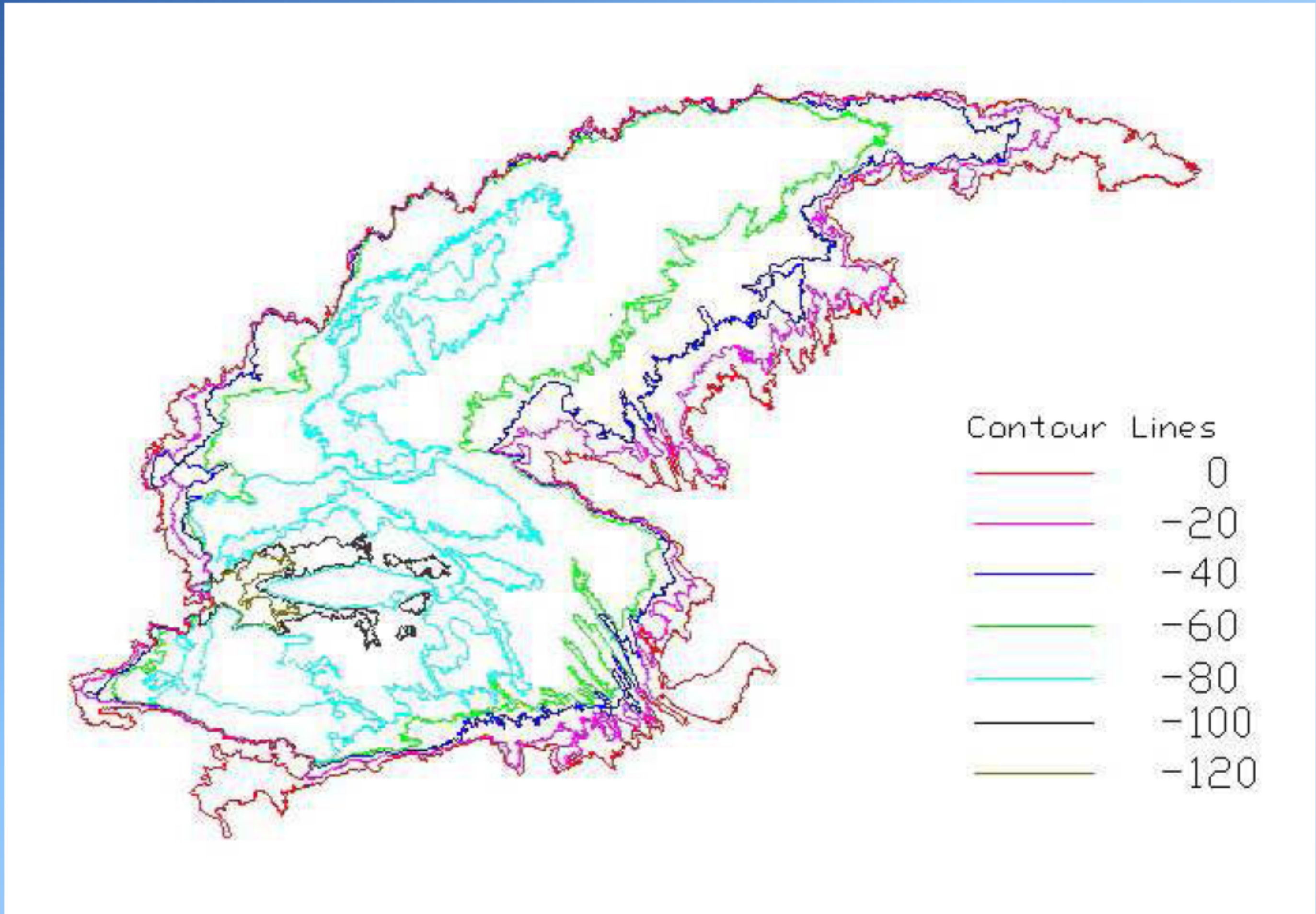
Contour lines of Qattara Depression



Qattara Depression planar areas and water volumes at different contour levels. The zero contour level represents the boundary of the depression

Planar area [km²]	**Filled water volume [km³]**	**Contour level**
19,605	1,213.0	0
17.646	839.0	20
15,405	508.0	40
12,510	227.0	60
4,652	39.3	80
526	6.3	100
153	0.8	120

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Petrified tree logs in the Qattara Depression as dried up salt lake beds and shifting sand.

View of Qattara Depression

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View into Qattara depression

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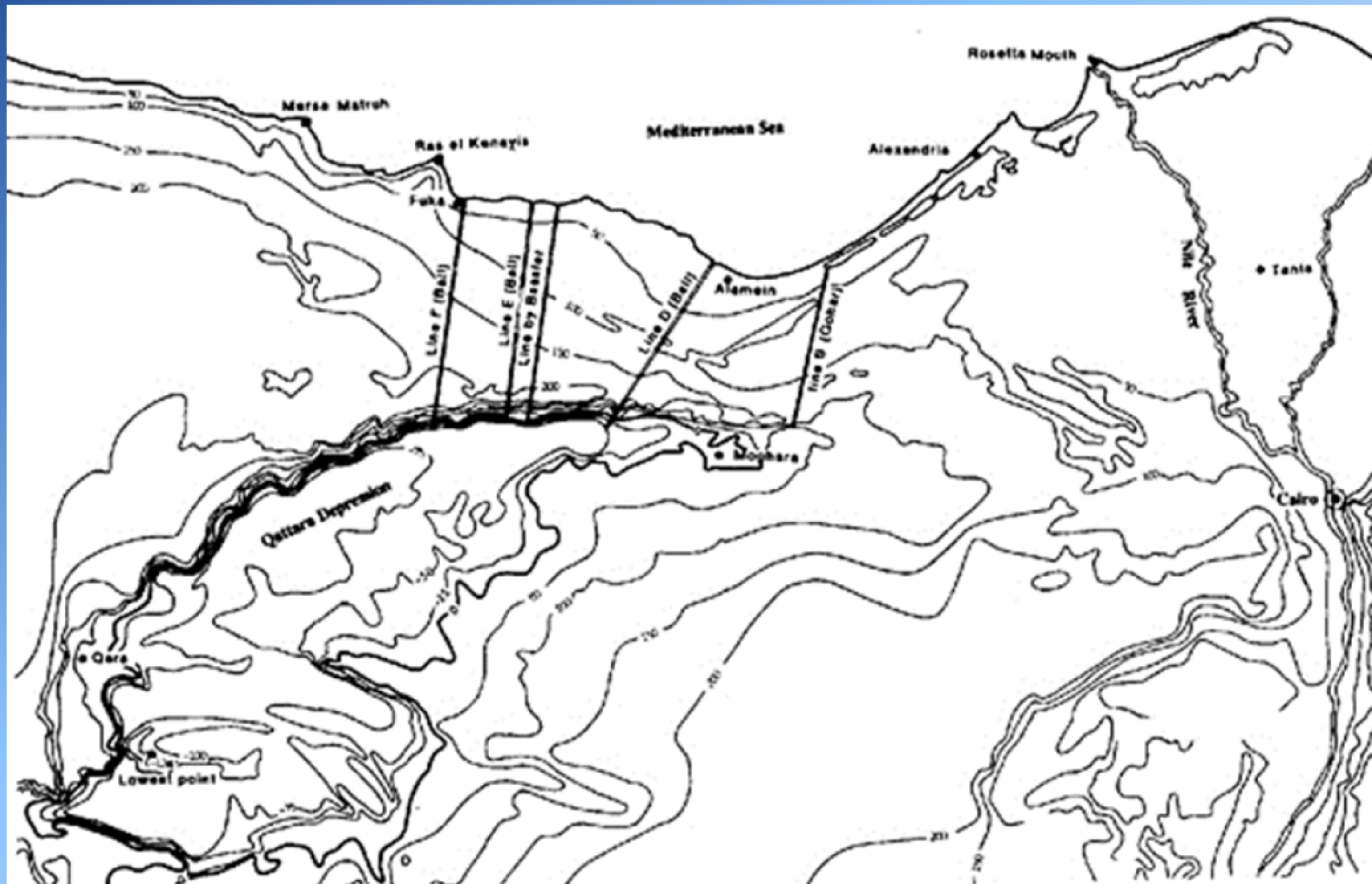
Topography of the Qattara Depression.



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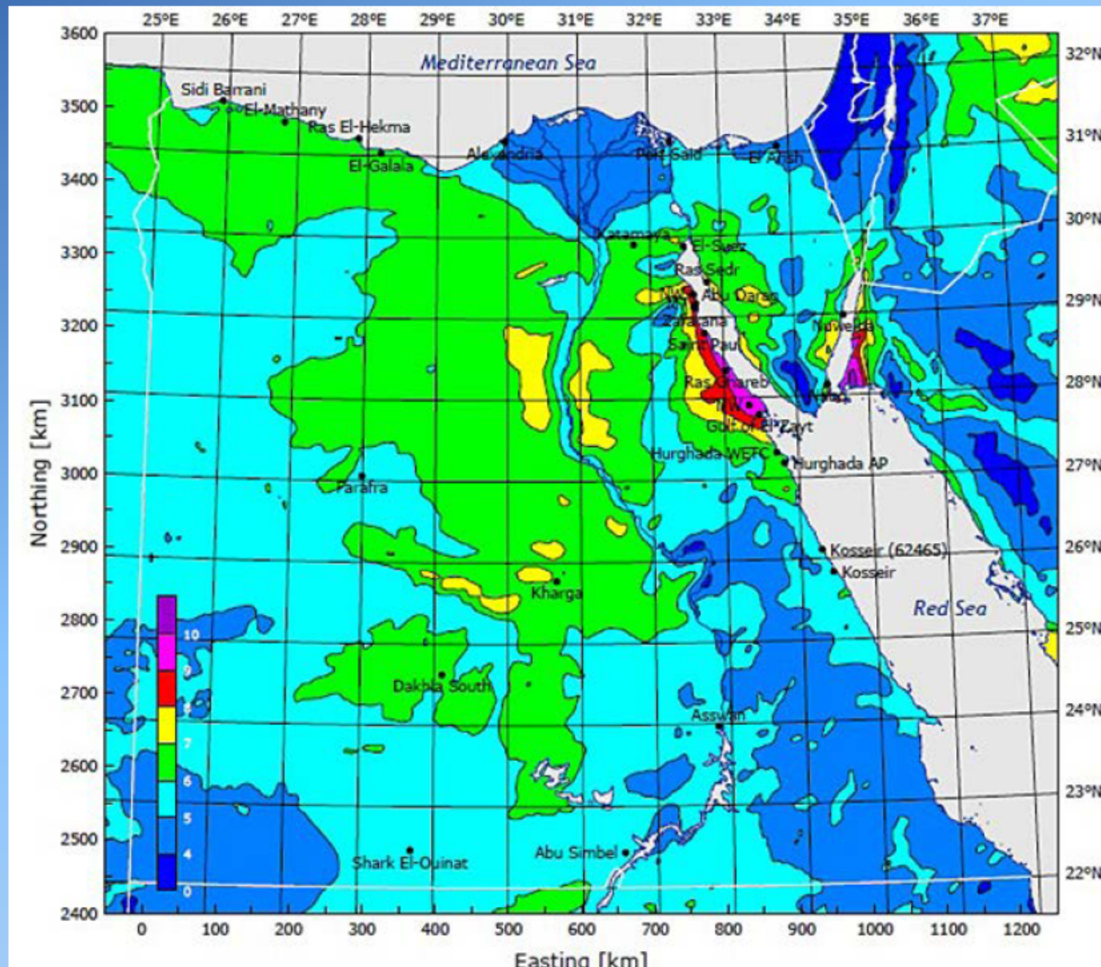
Wind resource map: mean wind speed at 50 m agl (above ground level). Source: Wind Atlas of Egypt.



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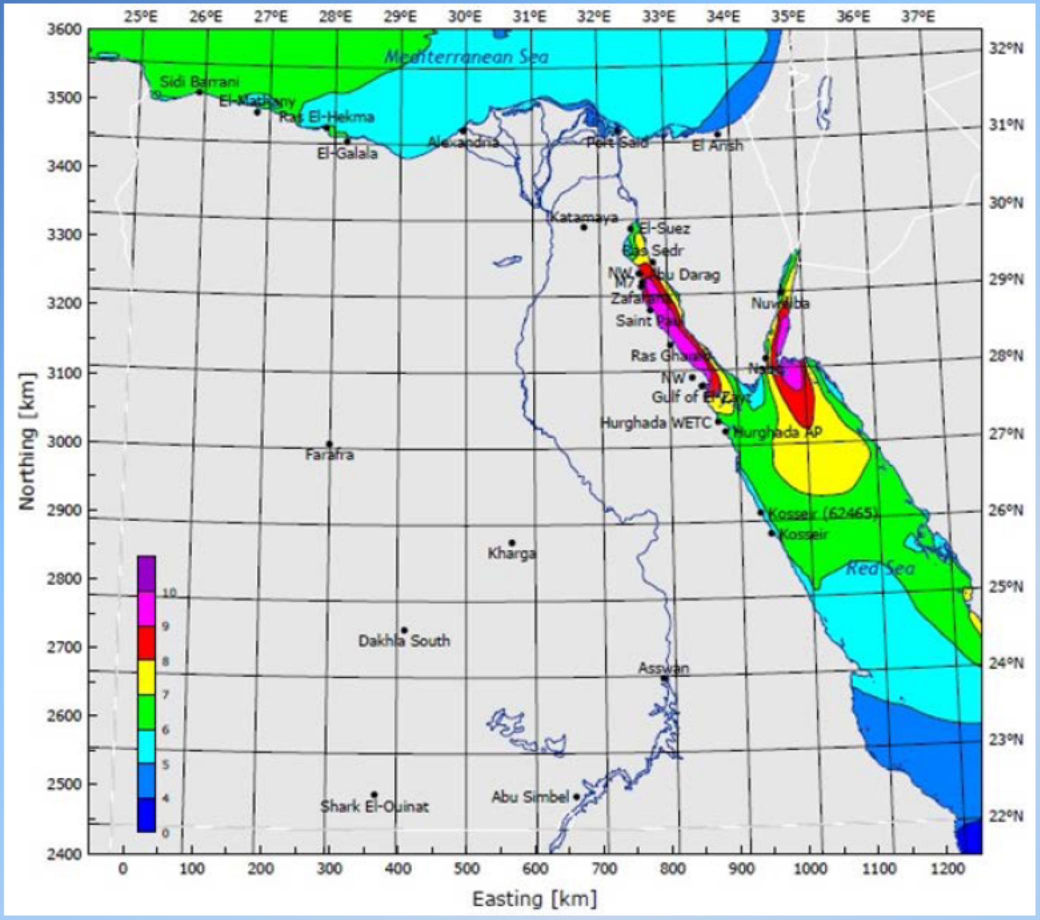
Offshore wind resource map: mean wind speed at 50 m above ground level, agl. Source: Wind Atlas of Egypt.



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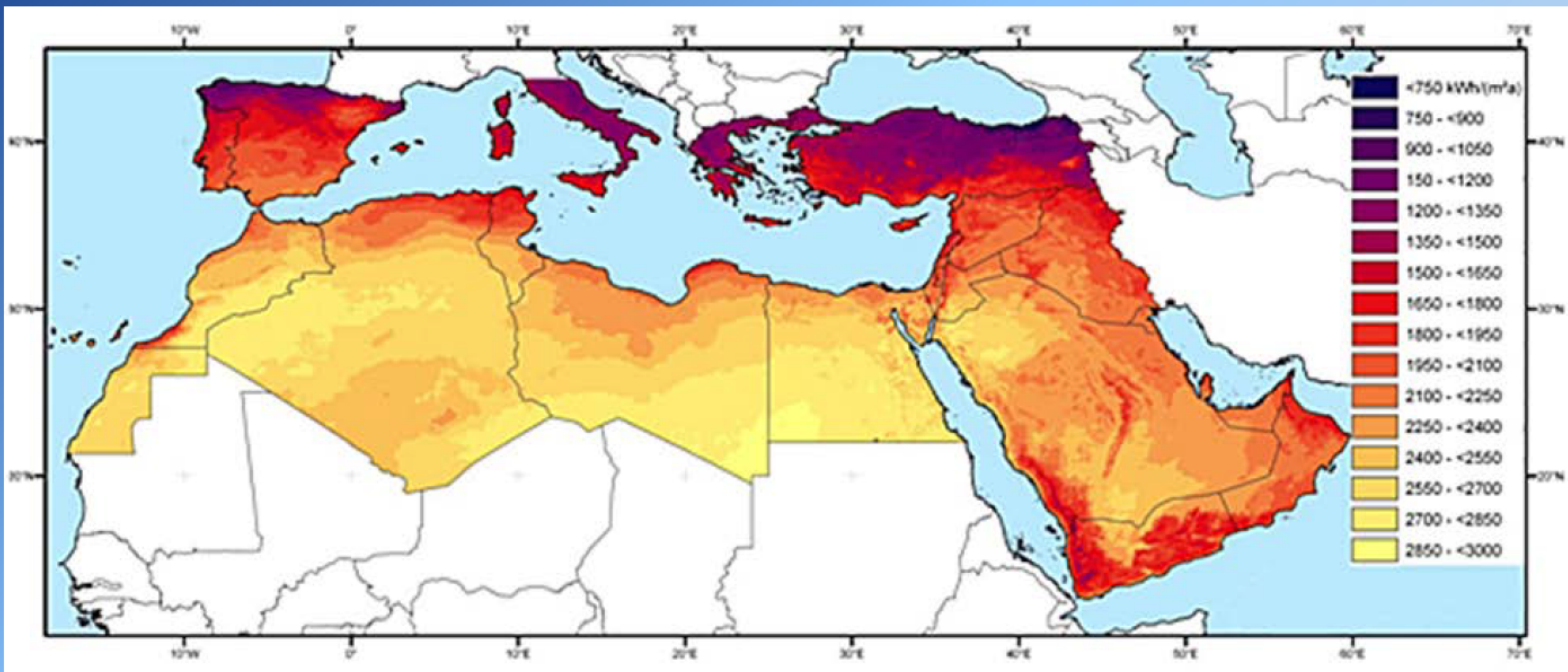
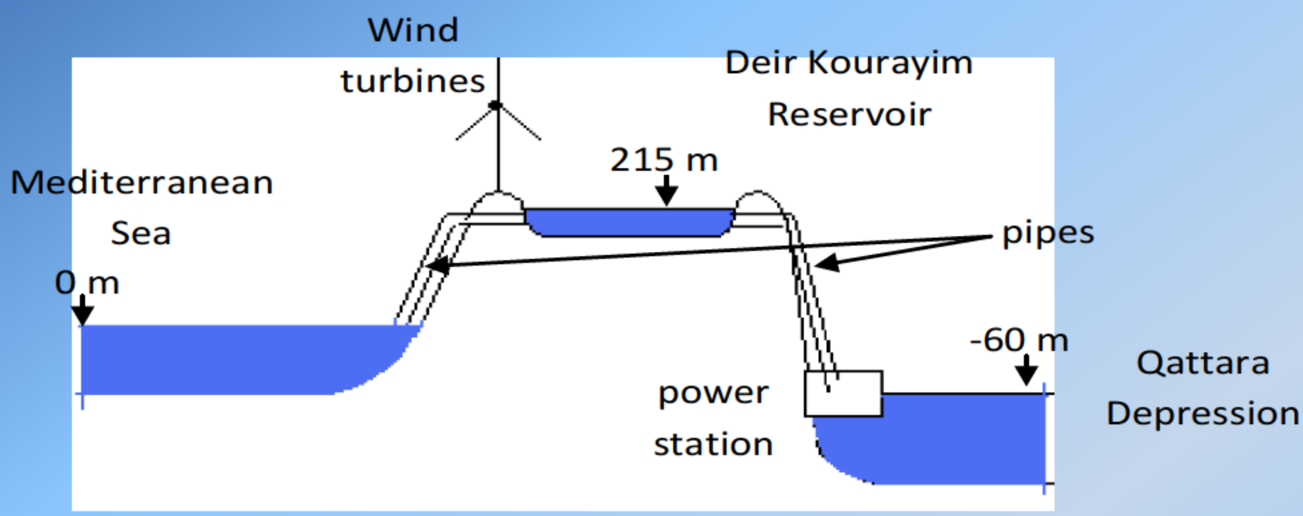
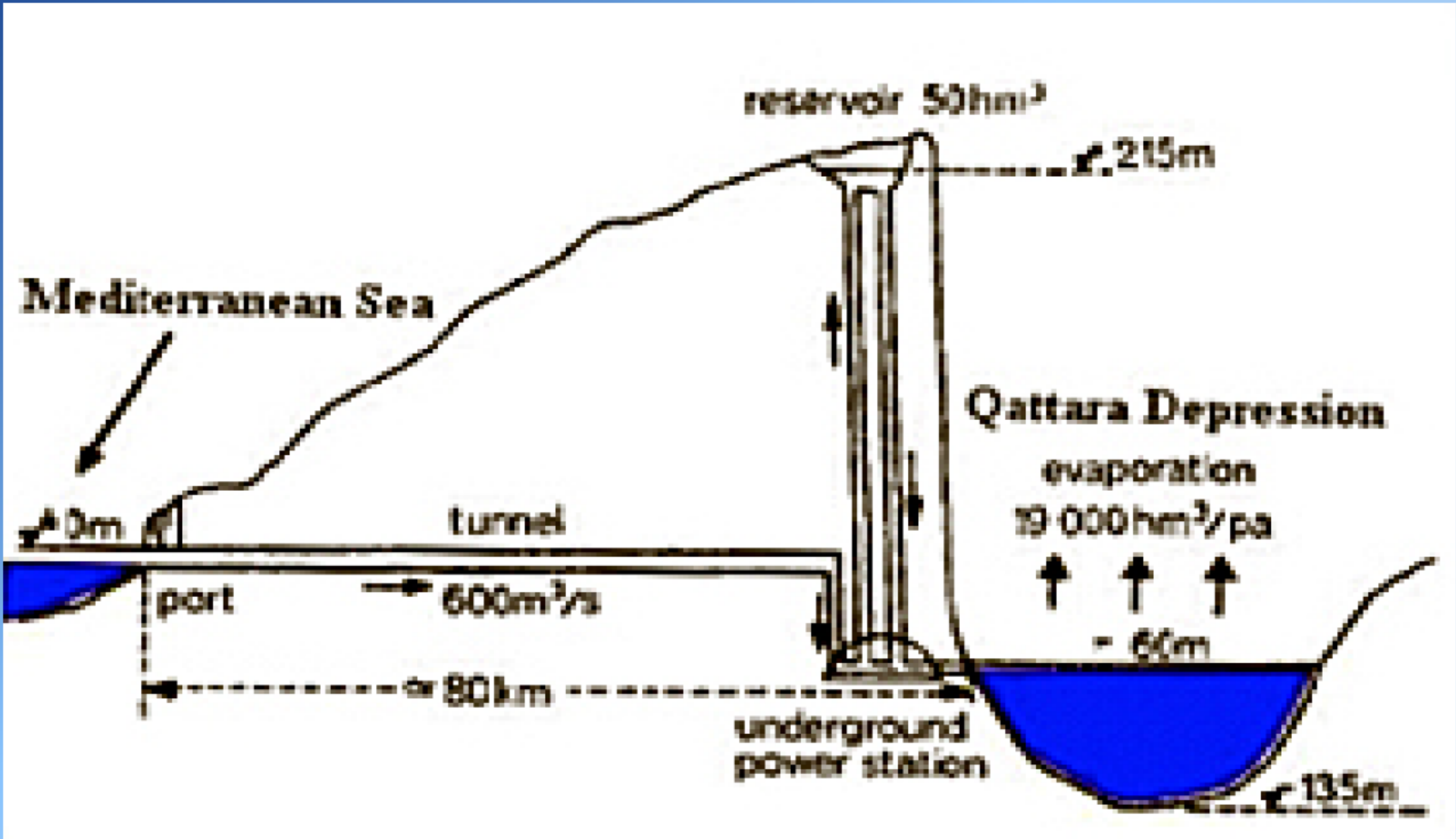
Annual Integrated Direct Normal Irradiation [kWh / (m².yr)] for the year 2002. Source: desertec.org.



Proposed approach with wind turbines and pipes at the Qattara Depression



Previously suggested design with a tunnel and pipes for pumped storage [3].



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Surface area and water volume at different filling levels in the Qattara Depression

Filling level [m]	Surface area [km^2]	Filled water volume [km^3]
-40	15,400	508
-60	12,500	227
-80	4,650	39.3
-100	526	6.3

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Economical comparison between the two considered approaches.

	Tunnelling Approach	Proposed Pipes + Wind farms
Capital cost (excluding the power block and the pipes between reservoir and depression)	$1.98 billion	$5.52 billion
Average power output	338 MWe	1,550 MWe
Initial cost per unit of installed capacity	5,860 $/MWe	3,560 $/MWe

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DISCUSSION

The energy mix of the future has to come from many different renewable energy sources. Due to the natural abundance of wind and solar energy, large scale storage units have to be built. Pumped hydro storage is one of the best possibilities. At the Qattara Depression Project, the three main sources of renewable energy – wind, solar and hydro – can be combined to overcome the wind's and solar intermittencies and to supply Egypt with renewable base and peak power electricity. This work proposes a both safe and economical way of using the topography of the Qattara Depression. The electricity from large wind farms drive motors that pump sea water from the Mediterranean Sea to the higher Deir Kourayim reservoir avoiding the negative effect of the wind intermittency. The stored water is then released into the Qattara Depression and forms a lake at 60 m below sea level. The resulting power output can be either used for base load supply only, or for both base and peak loads. In addition to the electricity generation and water desalination, the region with the lake can become a new tourist destination comparable to that at the Red Sea. Due to the high solar evaporation rate, salt and other minerals such as potash as a fertilizer can be eventually be mined from the depression and thousands of new jobs can be created.

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Thank you

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