NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Future of Solar Energy in Egypt

What do we expect from the future Energy?

Clean, Reliable, Secure, Sustainable, Affordable

Dr.-Ing. Hani El Nokrashy
hn@nokrashy.net
in cooperation with MANSOURA University, Egypt

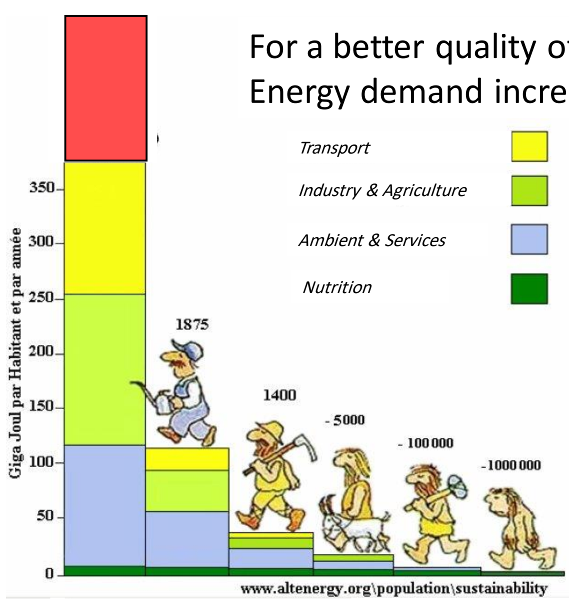
NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Energy and Humanity

2020
+ Energy for Desalination

World oil production In 2020 = 30 Billion Barrel/year

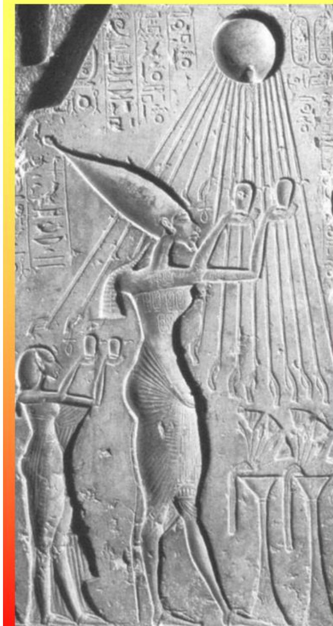
For a better quality of life
Energy demand increases



Sun Power = 1 Million Barrels of Oil per km² on Egypt's deserts / year

… **only when the sun shines.**
Storage of energy to bridge the night is essential, it needs at least 14 hours of storage for full load operation to bridge the night safely in winter.
Only under this condition a conventional power stations can be 100% replaced.

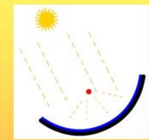
NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy



The sun rays in Egypt are direct sun rays, not mainly scattered as in Europe. They consist of two main components:

Light and **Heat**

Only direct sunrays can be focused with mirrors, thus high temperatures occur.



Part of the heat collected during the day is stored for use during the night

Heat storage in molten salts is the key issue to operate day and night

Heat is used to produce steam that drives a conventional steam turbine

Echnaton adoring the sun's power represented by slim sunrays that end with bless offering hands

1

To get an idea about the general frame of this discussion, some questions have to be cleared

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Question 01:
What is sooo special about ELECTRICITY?
Other than any product; Electricity **MUST** be consumed in the same fraction of a second of its production. Mass storage is not available (yet).
Storage of electricity is not economical; heat storage in contrast, is economically achievable. That is why heat storage works fine in electricity production with Concentrating Solar Power (CSP).
A conventional Power Station (PS) operates 24/7; and is mainly characterized by two important parameters:

- Its availability "On Demand"
- Its "Capacity Factor" (CF) 70 - 80%

CF = Equivalent full load time divided by hours of the year (8760 hours)

Renewable Energies vs. Conventional PS

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Question 02: What about Renewable Energies?

They can be classified in two categories:

1. Fluctuating: these are Wind, Solar PV and Hydro from small rivers with little Reservoirs, Wave and Tide. They are NON-Controllable, thus cannot follow demand, they deliver electricity just when they can.
2. "On-Demand", yielding exactly same performance like fossil power stations; these are:
   A) Hydro from big reservoirs like the Aswan High Dam or lakes on top of high mountains like those in Scandinavia.
   B) Solar Thermal with Heat Storage that allows bridging the night.

Usually when mentioning Renewables, only fluctuating resources are in mind; mainly Solar Photo-Voltaic and Wind. These need conventional power stations as "**Hot-Stand-By**" to start immediately in the supply gaps from the RE

Storage of Energy

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Question 03:

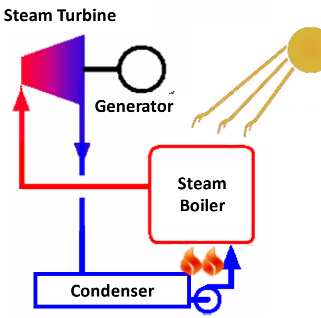
Batteries are the classical way to store electricity, it is a chemical storage. Storage is fine; however, it is always limited. What happens if the sun is not available for 2-4 days like "Khamaseen" or rain storms?

In Egyptian deserts, a maximum of 10 days per year may be without sun, which is less than 3% of the year. A stand-by fossil PS is waste of resources. CSP offers for these few days an economical solution, since the heat of the sun is stored, a device to heat the stored medium is easily installed and a tank for storage of bio-gas must be available, in exceptional cases natural gas may be used to bridge the few days without sun.

An integrated burner to heat the storage medium, usually a mixture of molten salts, is inexpensive. This will be the **SAFETY VALVE** to ensure interruption-free operation 24/7

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

CSP is a steam power station operated by the Sun




Source: SIEMENS

Answer to Question 03:
If the sun disappears for 2-4 days; then bio-fuel is used as a
Safety Valve
to secure reliable 24/7 electricity production

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Available Technology?

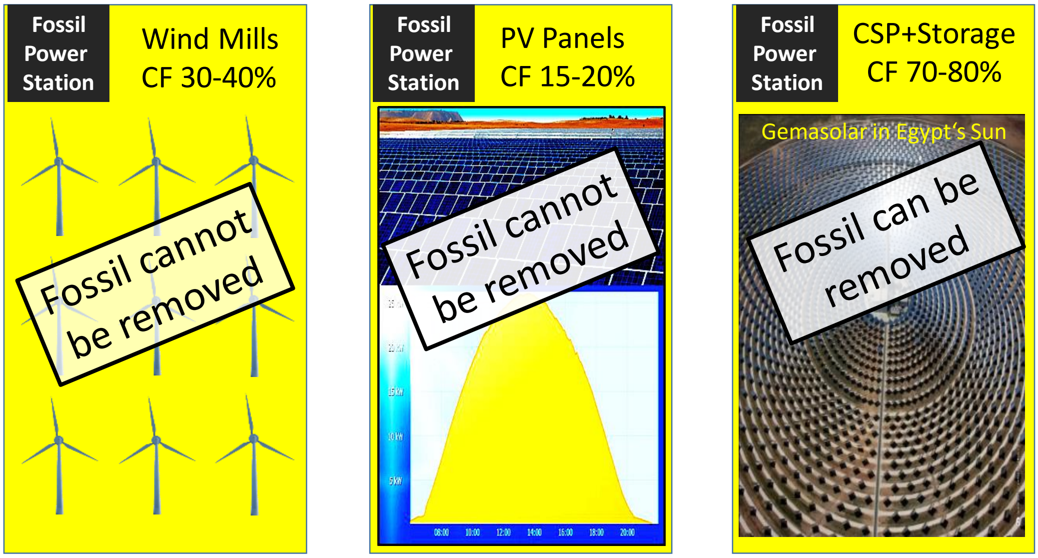
Since 2011, Gemasolar in Spain, including 15 h storage for full load


Source: Torresol energy

https://www.youtube.com/watch?v=GhV2LT8KVgA
https://www.youtube.com/watch?v=5nd7fGMXciA&nohtml5=False,

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Objective: Replacing a fossil Power Station of Capacity Factor 70%



We have to add to the costs of electricity of a certain source, the costs when it does not supply electricity

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Initial Capital costs is a difficult burden

Question 04: What is the quickest way to reduce capital costs?

Looking at the far goal, which is gradually converting electricity production in Egypt (later North Africa and the Middle East) to >95% renewables, two parameters must be considered:

- Levelized Cost of Electricity (LCoE) at the production point.
- Costs of infrastructure for electricity transportation to the demand point.

Since solar irradiation is available every where in Egypt, the preferable approach would be to build the power station as near as possible to the demand point. This in turn requires small power stations in contrast to the common strategy of big units to benefit from "economy of scale":

Mass production of standardized units is the most effective way to cut costs.

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Is CSP expensive? Let's calculate:

- One huge conventional Power Station 1 GW

Initial costs	1000 Mio $
Fuel consumption per year	700 Mio $
Fuel consumption in 5 years	3500 Mio $
Total costs after 5 years	4500 Mio $

+ 1000 Mio $ for transmission infrastructure

- Several Solar Thermal power stations 1 GW (better performance than conventional)

Initial costs	4500 Mio $
Fuel costs	0 $
Costs after 5 years	4500 Mio $

Minimal transmission infrastructure

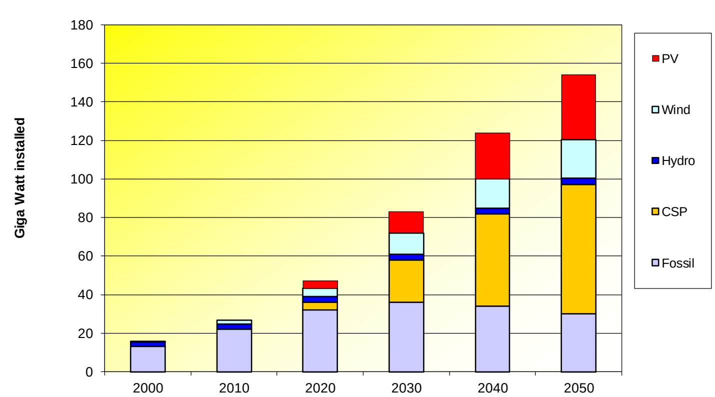
Cheapest electricity production in the sun belts

Within 5 years new Solar Thermal Power Stations can be financed just from the fuel savings. **Without a loan**

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

The need of a frame work

Increasing gradually the renewable share with standardized power stations solves electricity and water problems.
Local production reduces costs and transportation of large parts.



Installed Renewable capacity increases to 80% in 2050, while RE >95%

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Expandability, Flexibility and Supply security

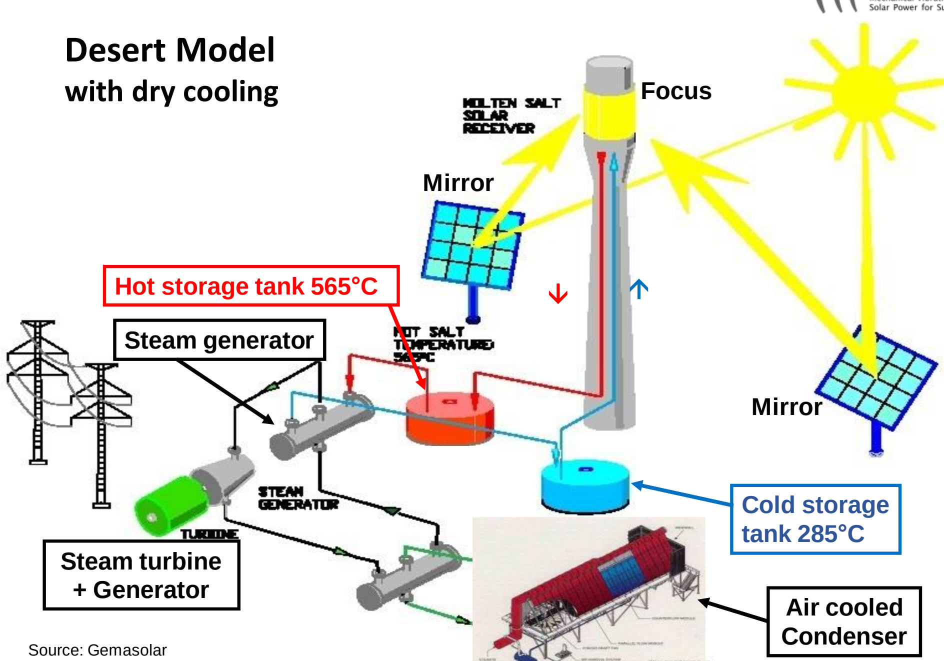
Question 05:

What is the best balance between flexibility, adaptation and costs?

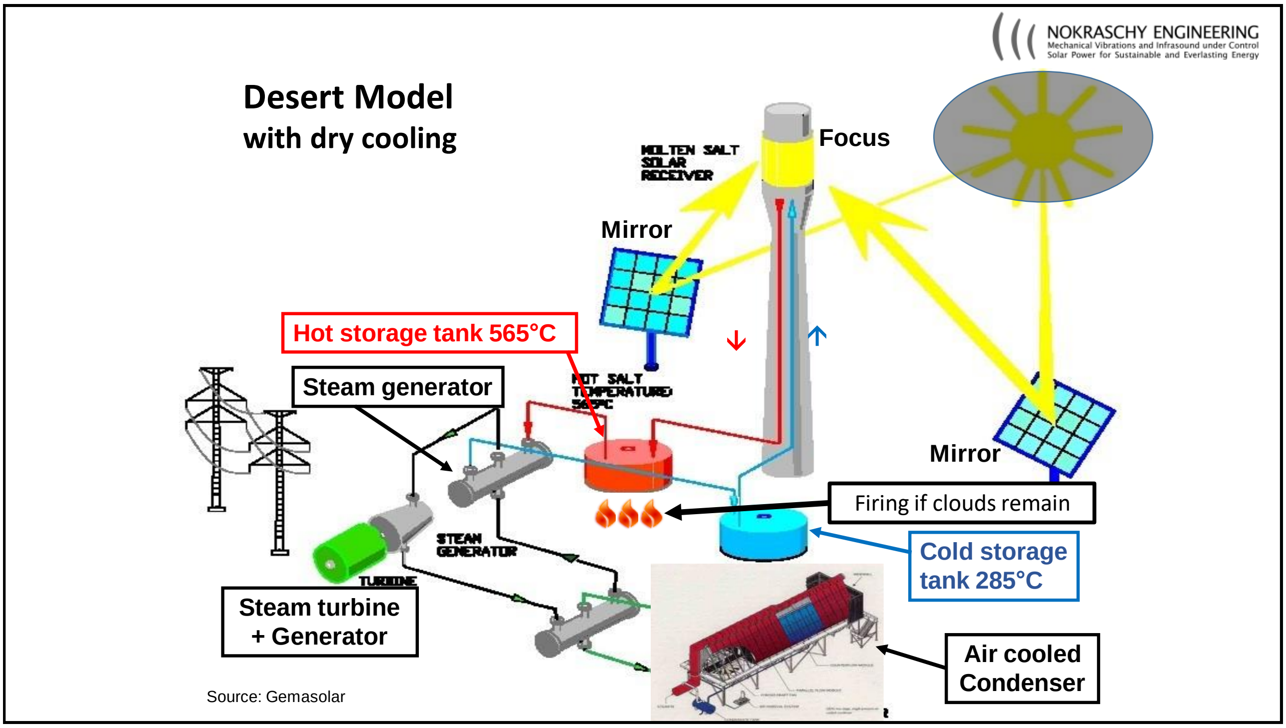
- Planned local grids of 5 Power stations (Khemesa) of equal capacity each 20 or 50 MW with a stand-by emergency fossil unit.
- Expansion of this system will end with 20% fossil installed, while delivered energy will be over 95% Renewable.
- The local grid will feed excess electricity in the main grid – if needed – thus reduce costs of main grid reinforcement.
- Faults in the main grid will not affect the local grids, thus better electricity supply reliability and security

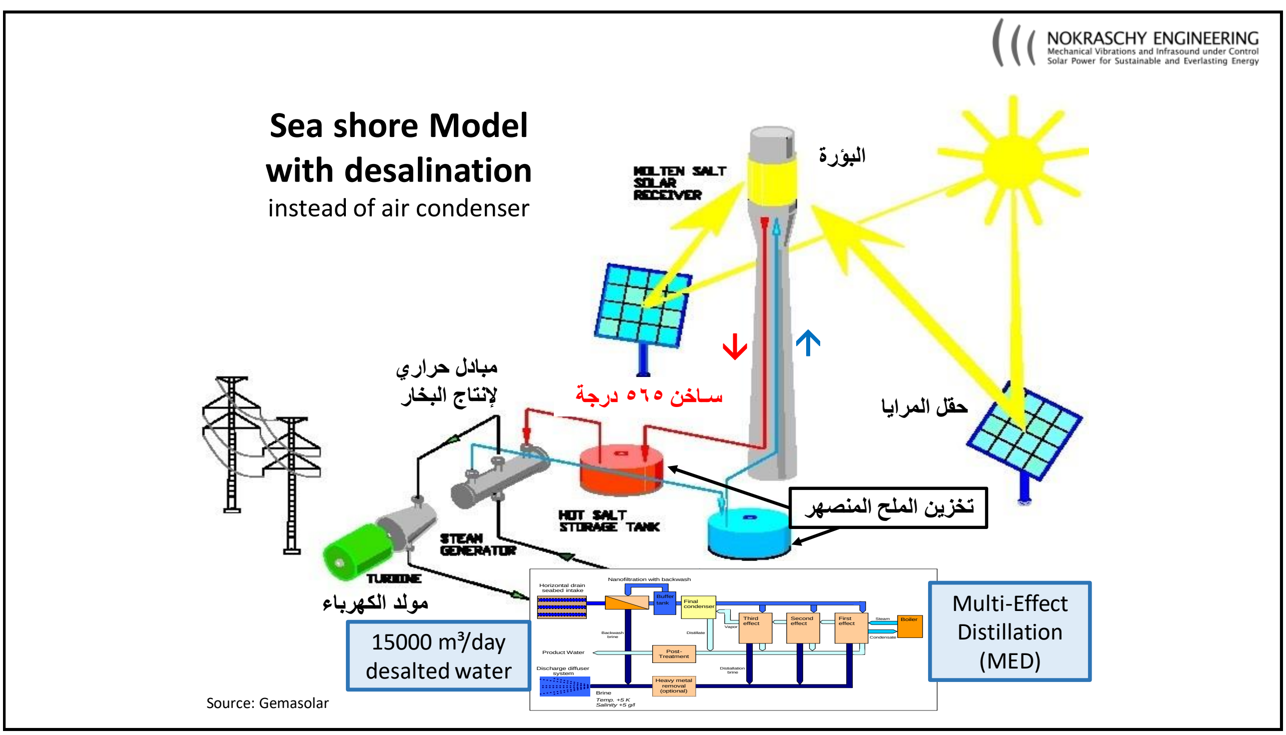
NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Desert Model
with dry cooling



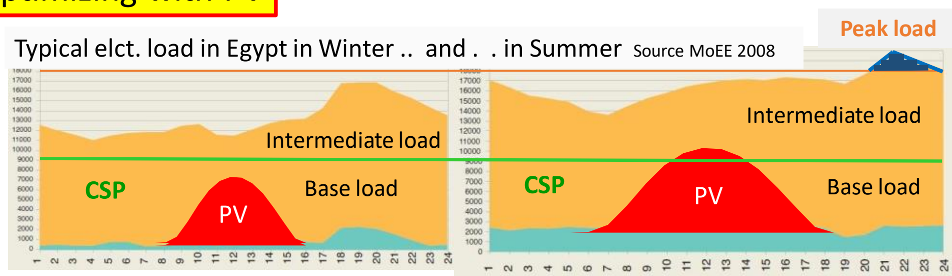
Source: Gemasolar


NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy
Desert Model
with dry cooling
MOLTEN SALT SOLAR RECEIVER
Focus
Mirror
Hot storage tank 565°C
Steam generator
HOT SALT TEMPERATURE 565°C
Mirror
Firing if clouds remain
STEAM GENERATOR
Cold storage tank 285°C
TURBINE
Steam turbine + Generator
Air cooled Condenser
Source: Gemasolar


NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy
Sea shore Model
with desalination
instead of air condenser
MOLTEN SALT SOLAR RECEIVER
البؤرة
مبادل حراري
لإنتاج البخار
ساخن ٥٦٥ درجة
حقل المرايا
تخزين الملح المنصهر
HOT SALT STORAGE TANK
STEAM GENERATOR
TURBINE
مولد الكهرباء
15000 m³/day desalted water
Multi-Effect Distillation (MED)
Source: Gemasolar

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Cost optimizing with PV



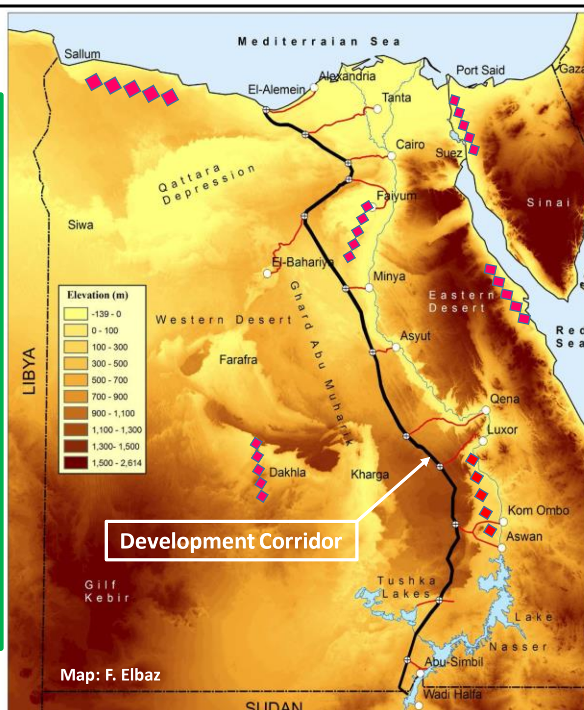
A local grid of 5 solar thermal power stations, can be completely self-sustaining 365 d/year

- Each local grid consists of 5 Standardized CSP power stations of same capacity.
- In winter, where the demand is 20% less than in summer, 4 power stations are sufficient, so the yearly periodic maintenance can take place for each one station in turn.
- Adding a PV field within the CSP power station, of peak capacity 50% of the nominal power of the turbine will enhance storage capability and avoid grid instability by PV distortion.
- Each local grid may be reinforced by a gas power station of same capacity as emergency

Decentralized

The geographical and demographic situation in southern Egypt - looking at future expansion - favours decentralized production and consumption of electricity rather than a unified grid all over the country

Scale of PS 100x enlaged



NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Electricity 24/7
365 days/year
w/o BLACKOUT

Local Mini Grids
Instead of huge Power Stations

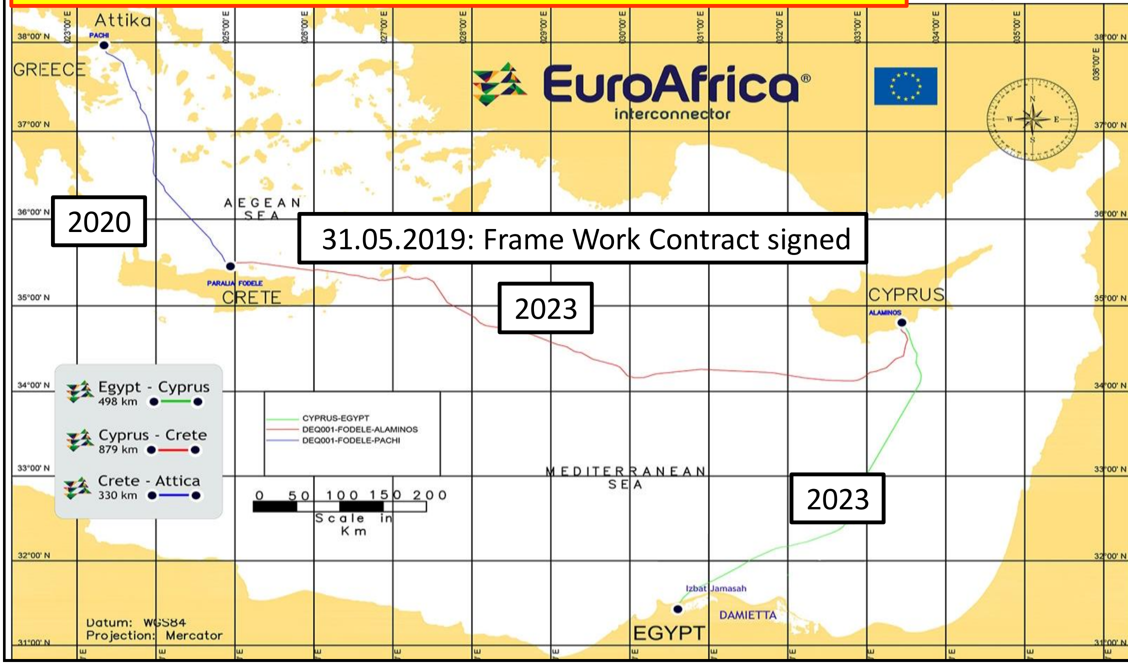
in the space between the "Development Corridor" and the Nile valley

each consisting of 5 equal solar power stations including 14 hours of storage

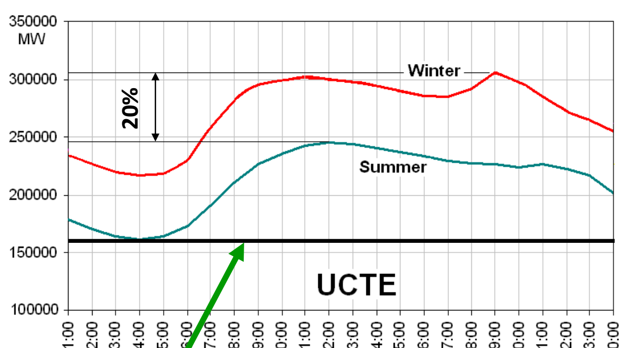
Clean, Secure and Sustainable Electricity for Egypt's Energy Future

Europe needs reliable renewable electricity ON DEMAND

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

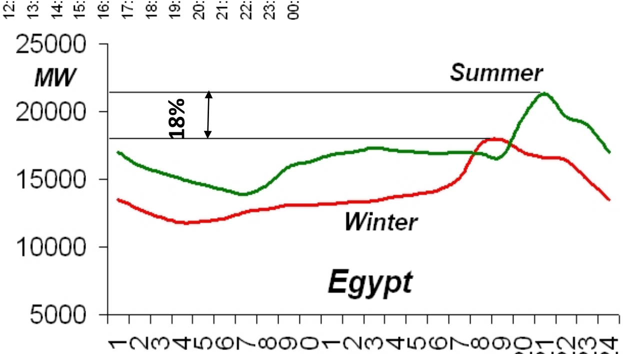


NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy



Outlook for 2050, Beside Seasonal Compensation between EU and MENA Grids ...

... also Security for Base Load in EU-Grid, since most power in EU is fluctuating



Source UCTE and statistics of MoEE Egypt

UNIKASSEL VERSITÄT

REMENA

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

REMENA joint Master degree in Renewables … needed for a sustainable future

NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Egypt has the possibility to lead the World towards
clean sustainable electricity and solar seawater desalination