# Napelemes fejlesztések a világban

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# Vázlat

- Naphőerőművek
- Solar cooling
- Létesítési ktg. - energiaár – LCOE
- Inverterek funkciói
- Inverterek elhelyezése

# Nem összekeverendő

- Naphőerőmű (Concentrated Solar Power – CSP)

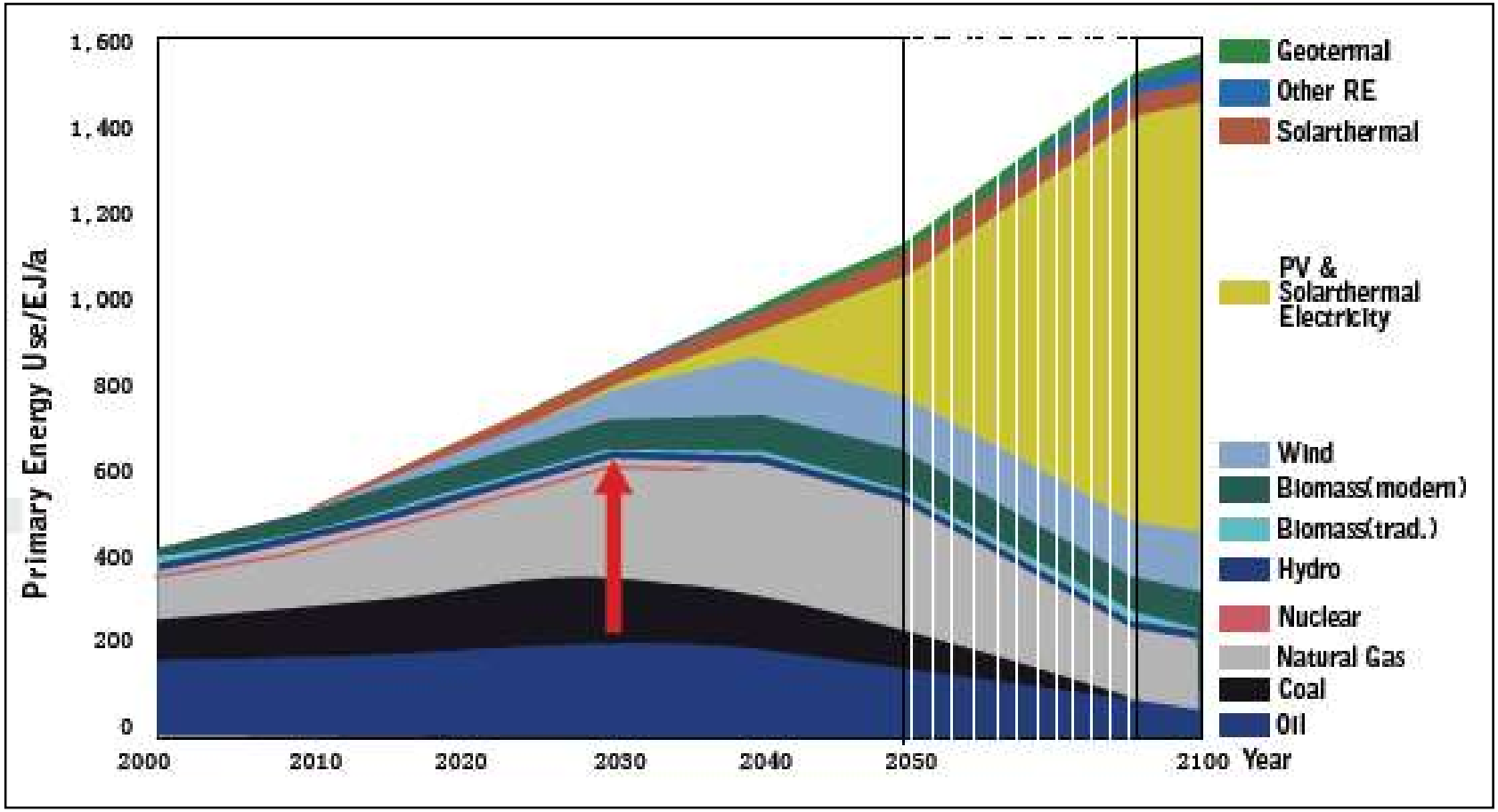
  napsugárzás –> villamos energia
- Napkollektor (solar thermal collector)

  napsugárzás –> hőenergia
- Napelem (PhotoVoltaics – PV)

  napsugárzás –> villamos energia

Naphőerőmű ≠ Napkollektor ≠ Napelem

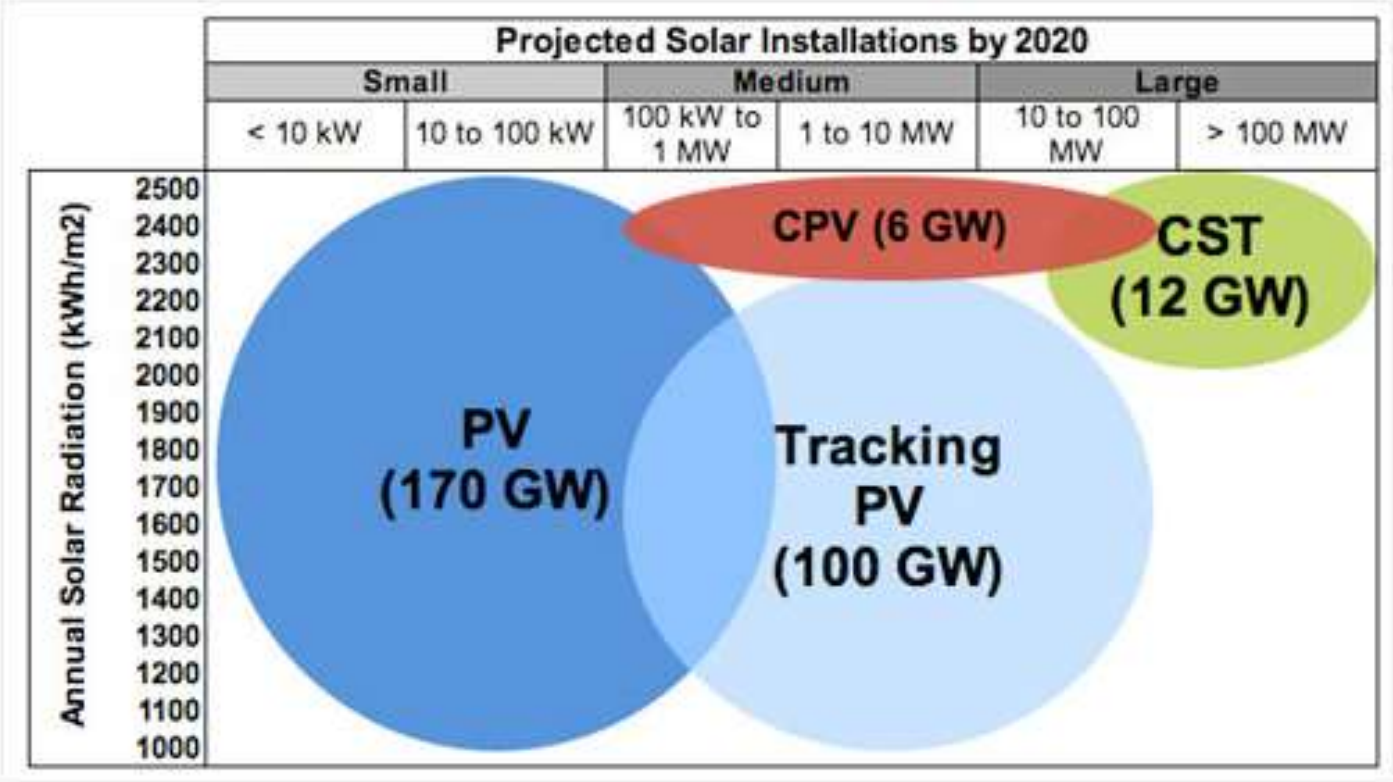
# EU Solar Roadmap






*Forrás: EU PV Platform*

# 2008 Industry Report




*PV Industry Report 2008*

# Európai éves besugárzási értékek

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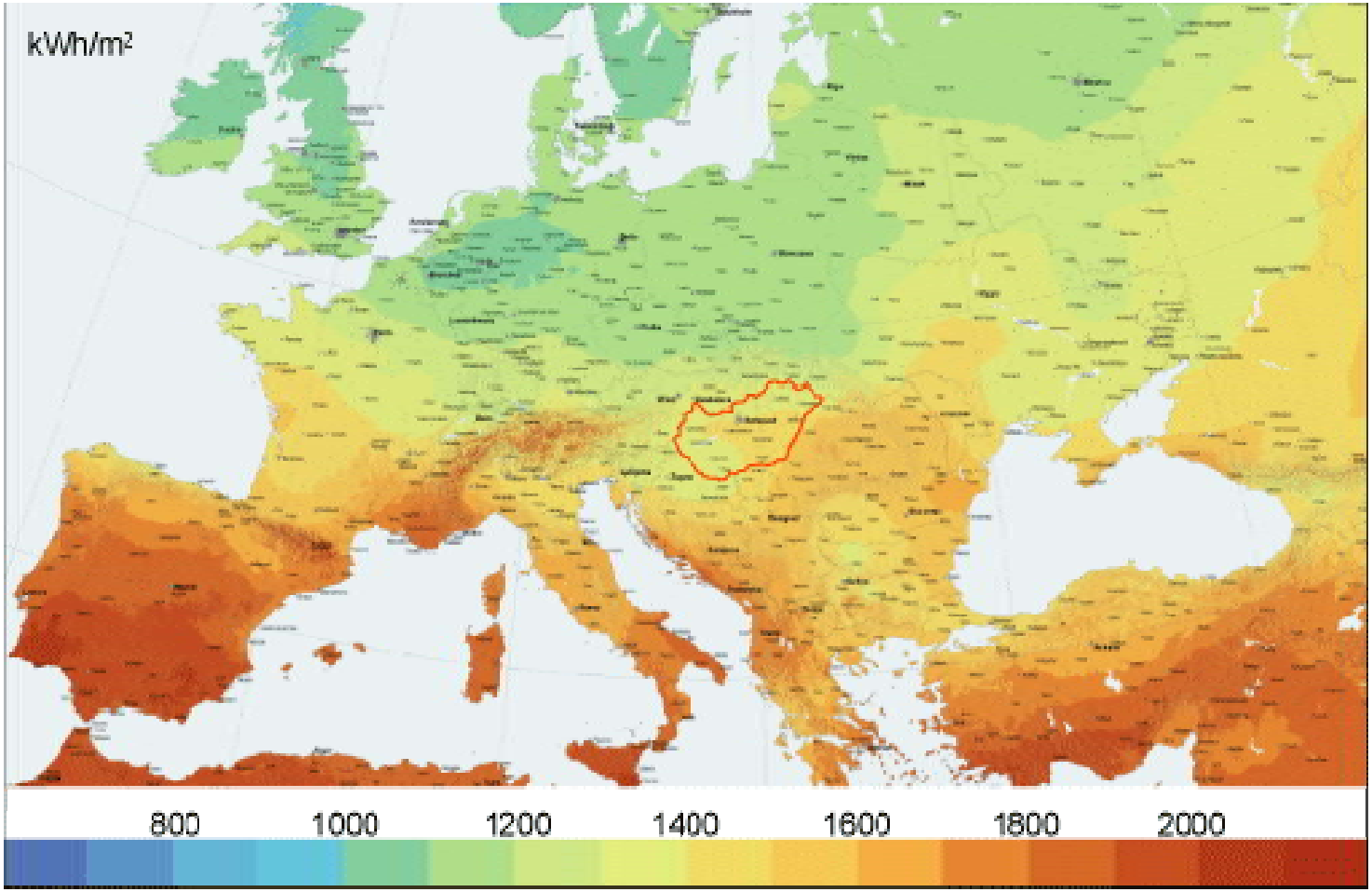


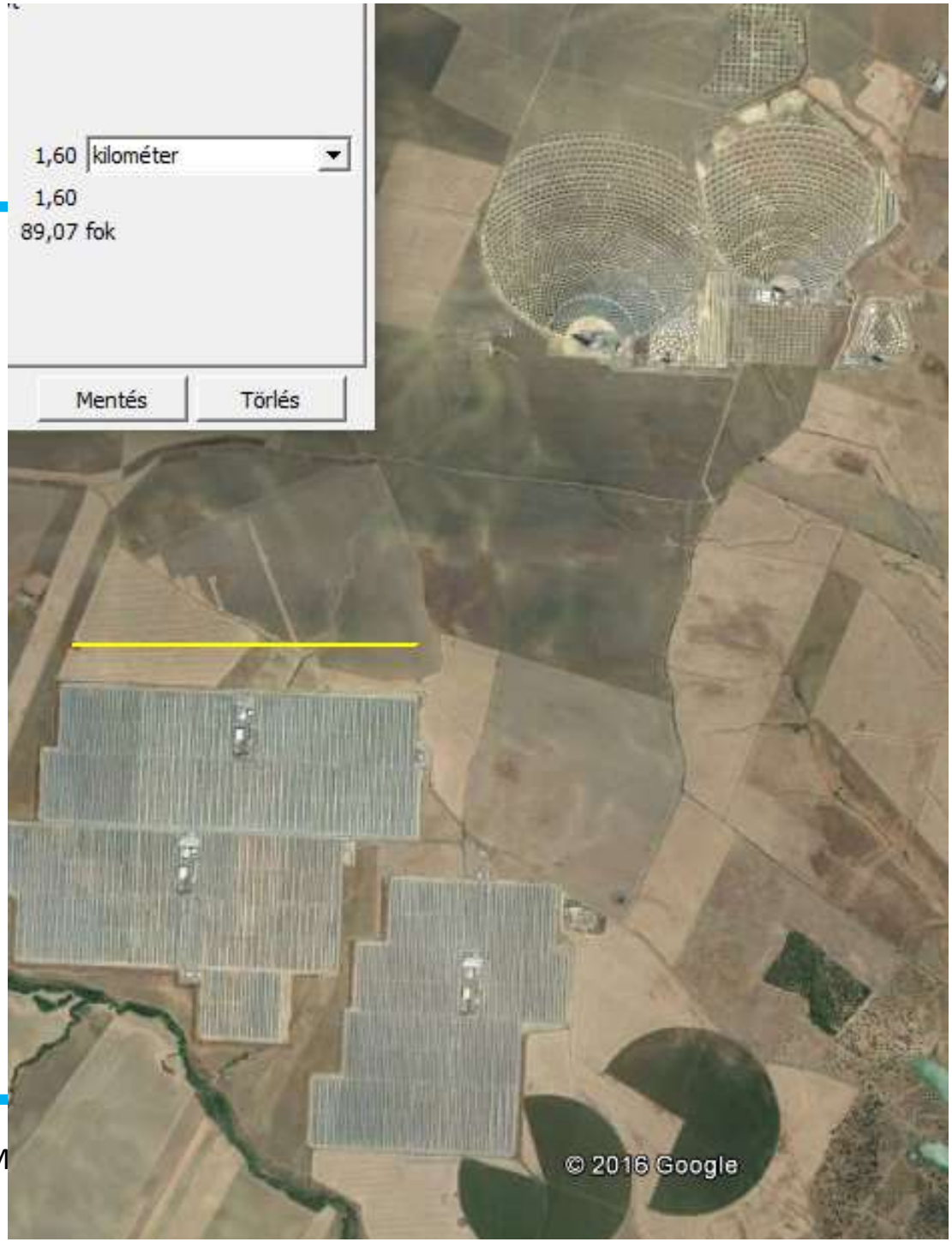
# Főbb Nap(hő)erőmű típusok

- Naptorony *(eng: solar tower, deu: Heliostat)*: Koncentrikus körökbe telepített nagy felületű és napkövető síklap tükrök irányítják a visszavert fényt a középpontban álló torony tetejére. Itt egy tartályban található a hőátadó folyadék, ami felveszi a hőt.
- Napteknő *(eng: solar trough, deu: Parabolrinne)*: Teknő alakú tükrök követik a Nap mozgását, a tükrök fókuszában egy cső található, benne hőátadó folyadék kering és veszi fel a hőt.
- Napkémény *(eng: solar tower, Solar chimney, Solar flue)*: Nagy földterületet borítanak kör alakú üveg vagy műanyagszerkezettel, ami a kör közepe irányába magasodik. Középen egy magas torony található, benne szélturbina vagy szélturbinák.

**(forrás: www.kekenergia.hu)**

# Solucar, Sevilla – naptorony

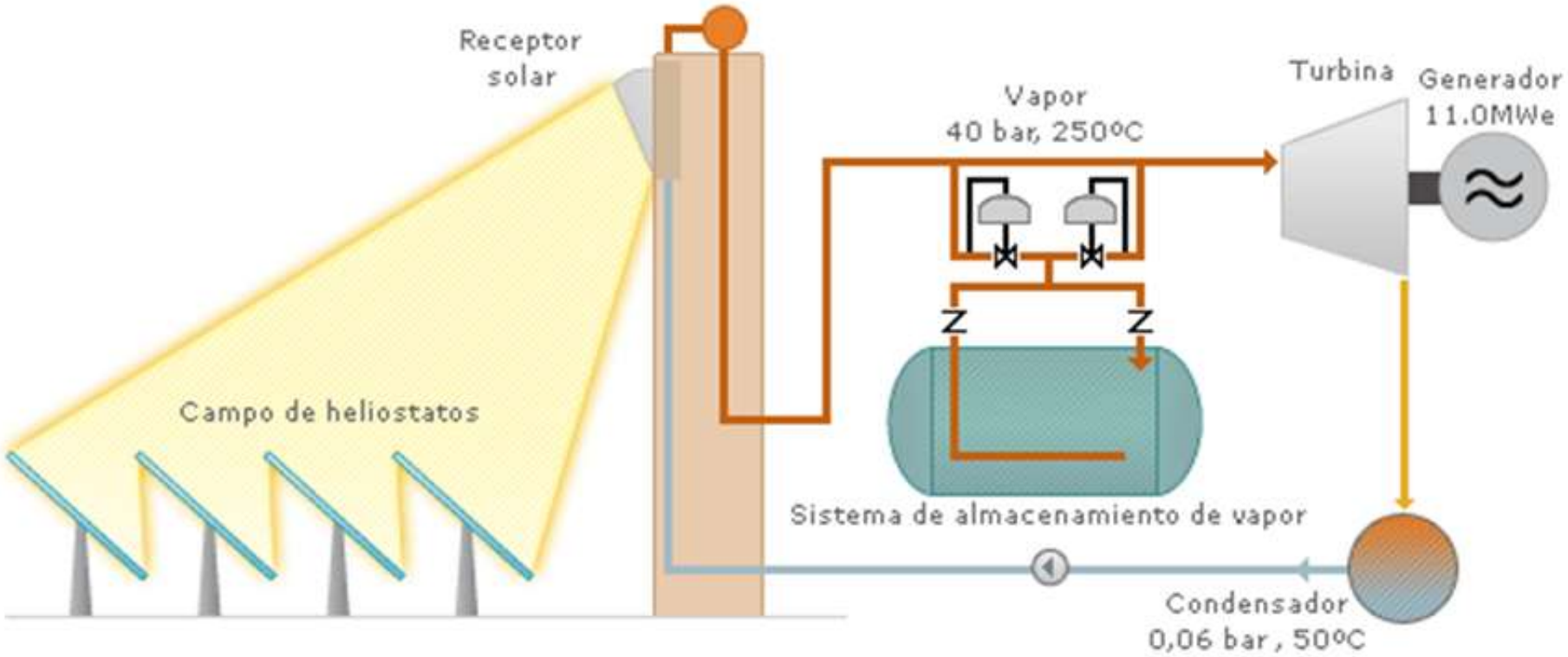
# Solucar, Sevilla



# Solucar, Sevilla

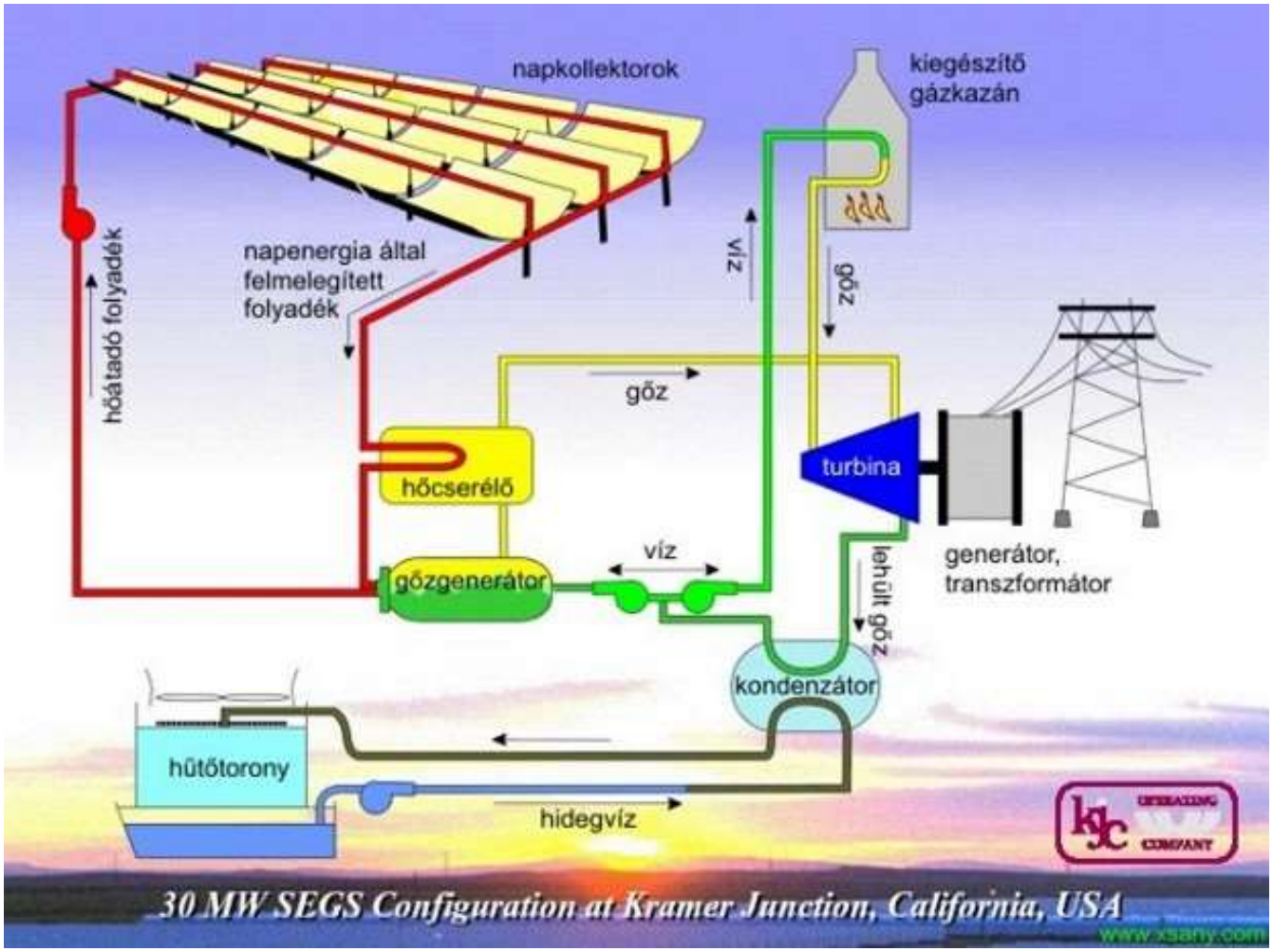
# Solucar, Sevilla

# Solucar PS10 (11 MW) www.solucar.es



# Solucar, Sevilla

# Kramer Junction erőmű, CA, USA




A

(forrás: www.kekenergia.hu)

# 3 erőműcsoport, 354 MW csúcsteljesítmény (+ földgáz tüzelés)

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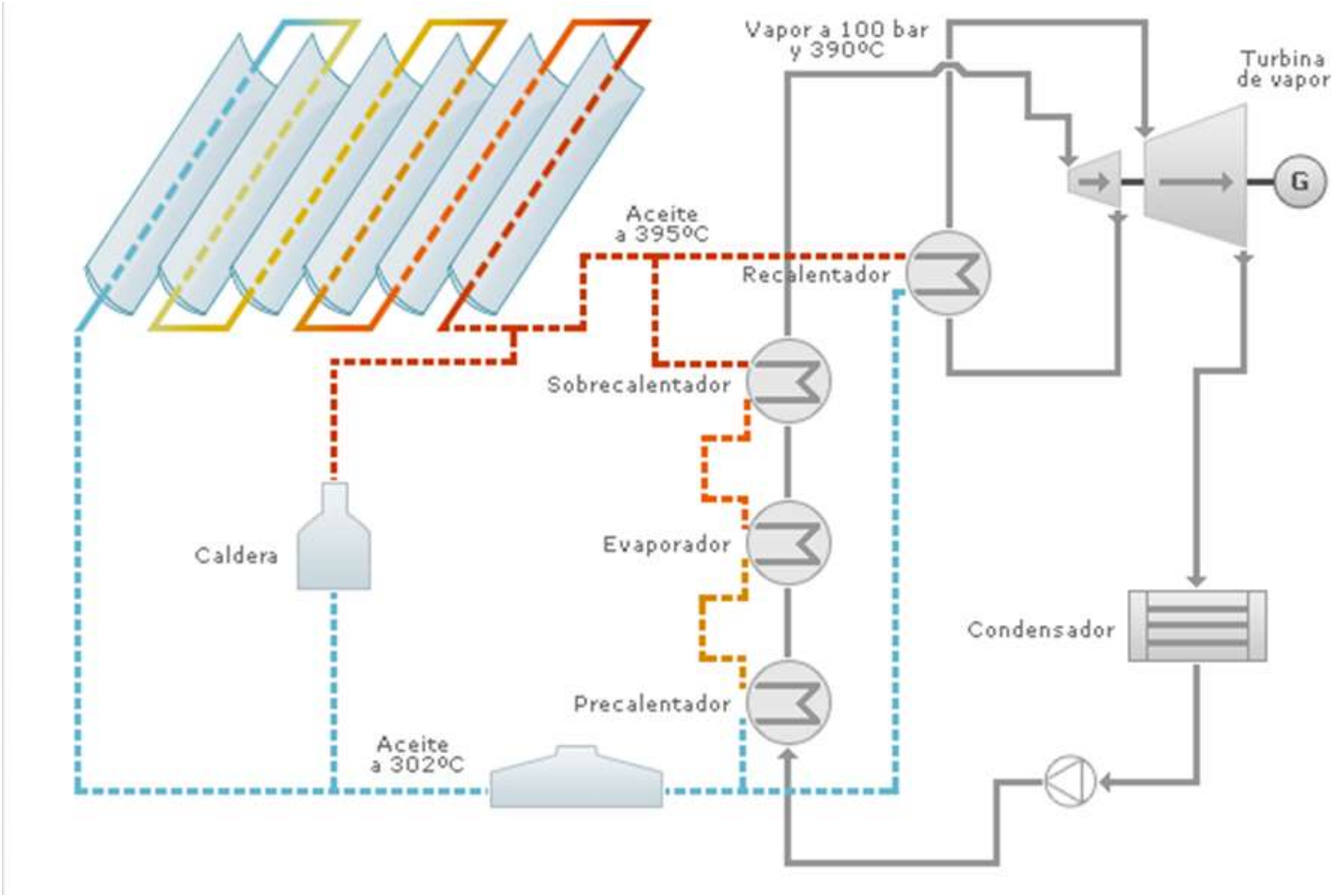
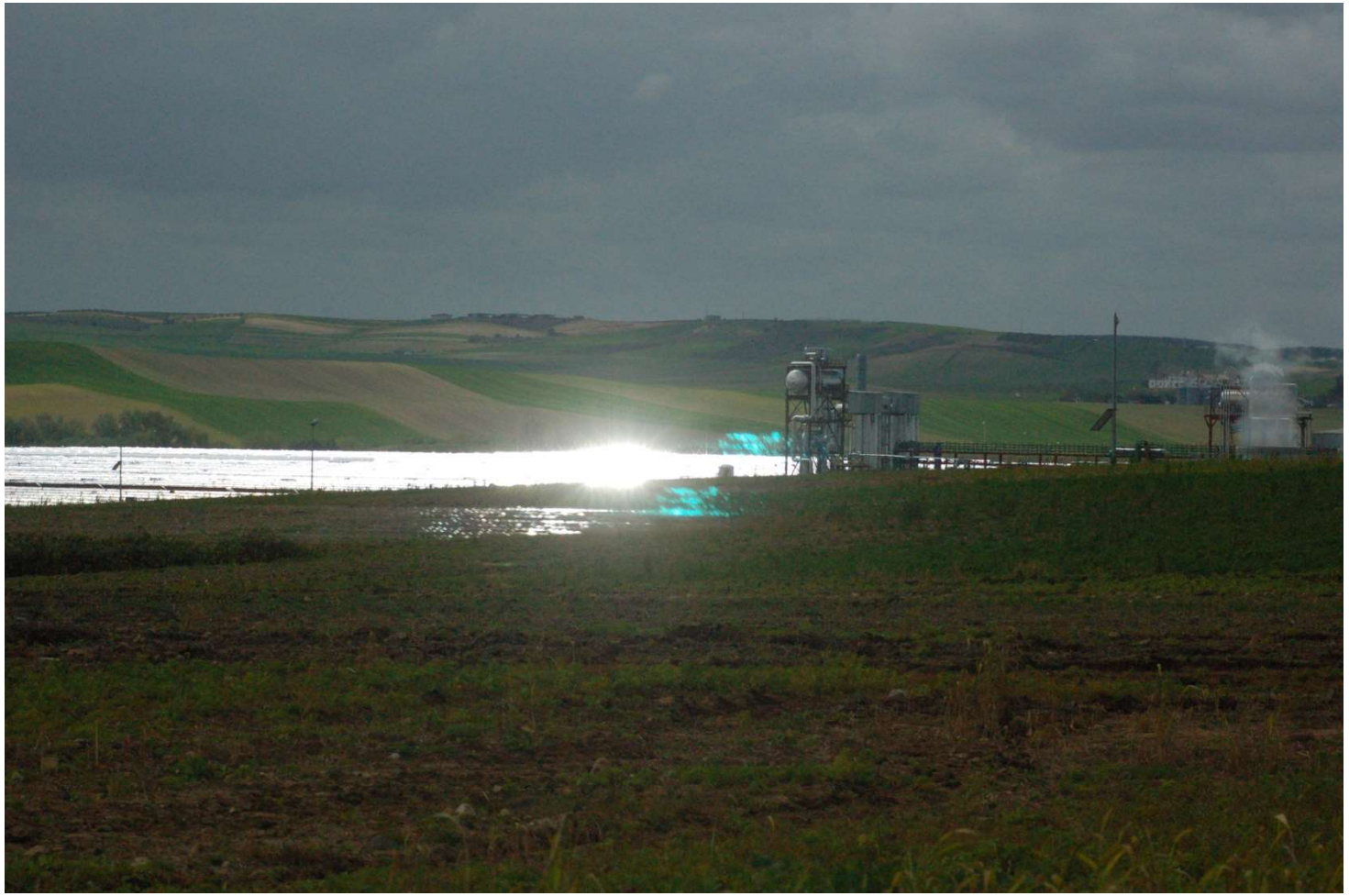
# Solucar, Sevilla – napteknő

# Solanova 50 MW www.solucar.es



# Solucar, Sevilla

# Solucar, Sevilla



# GEMASOLAR, Spain

# Quarzazate, Marocco, 2016 166 MW

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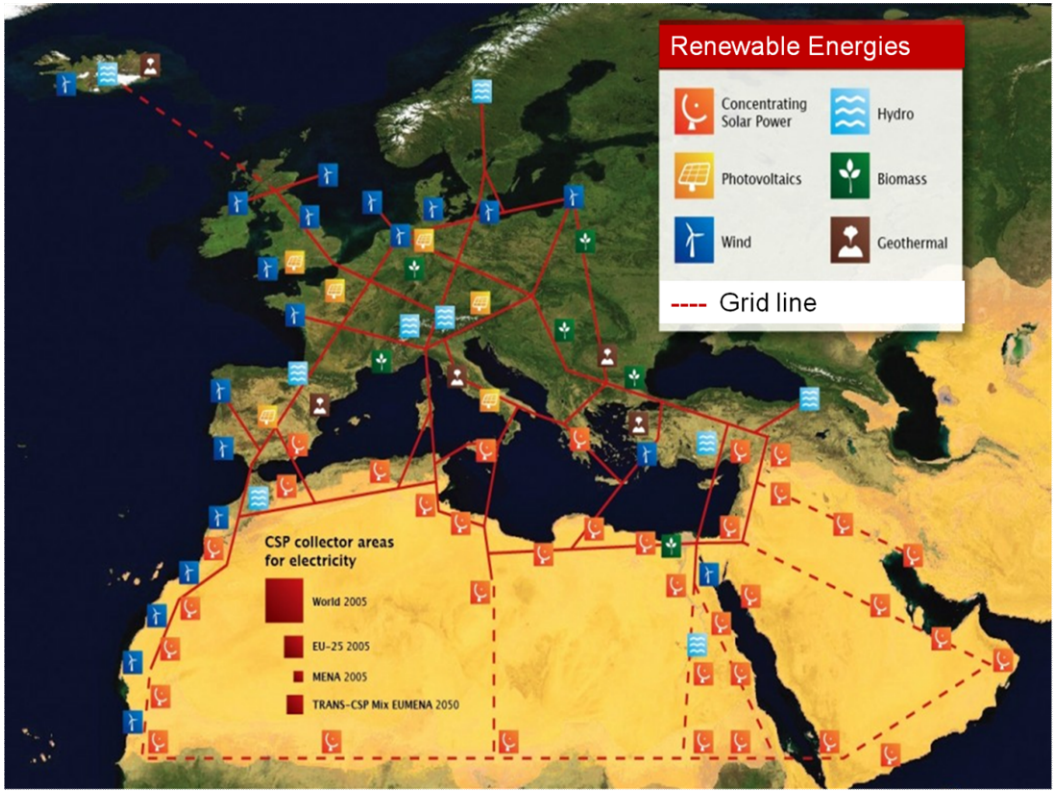
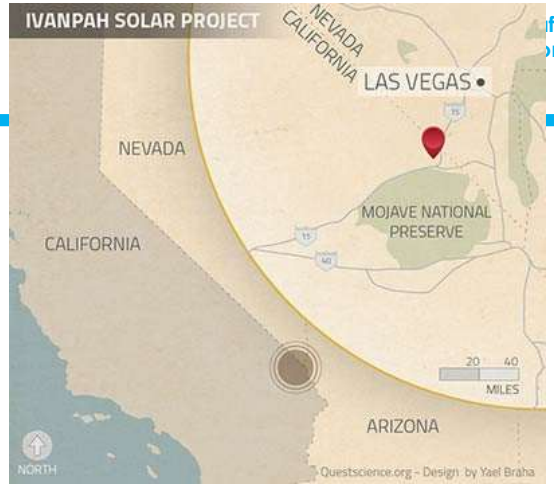
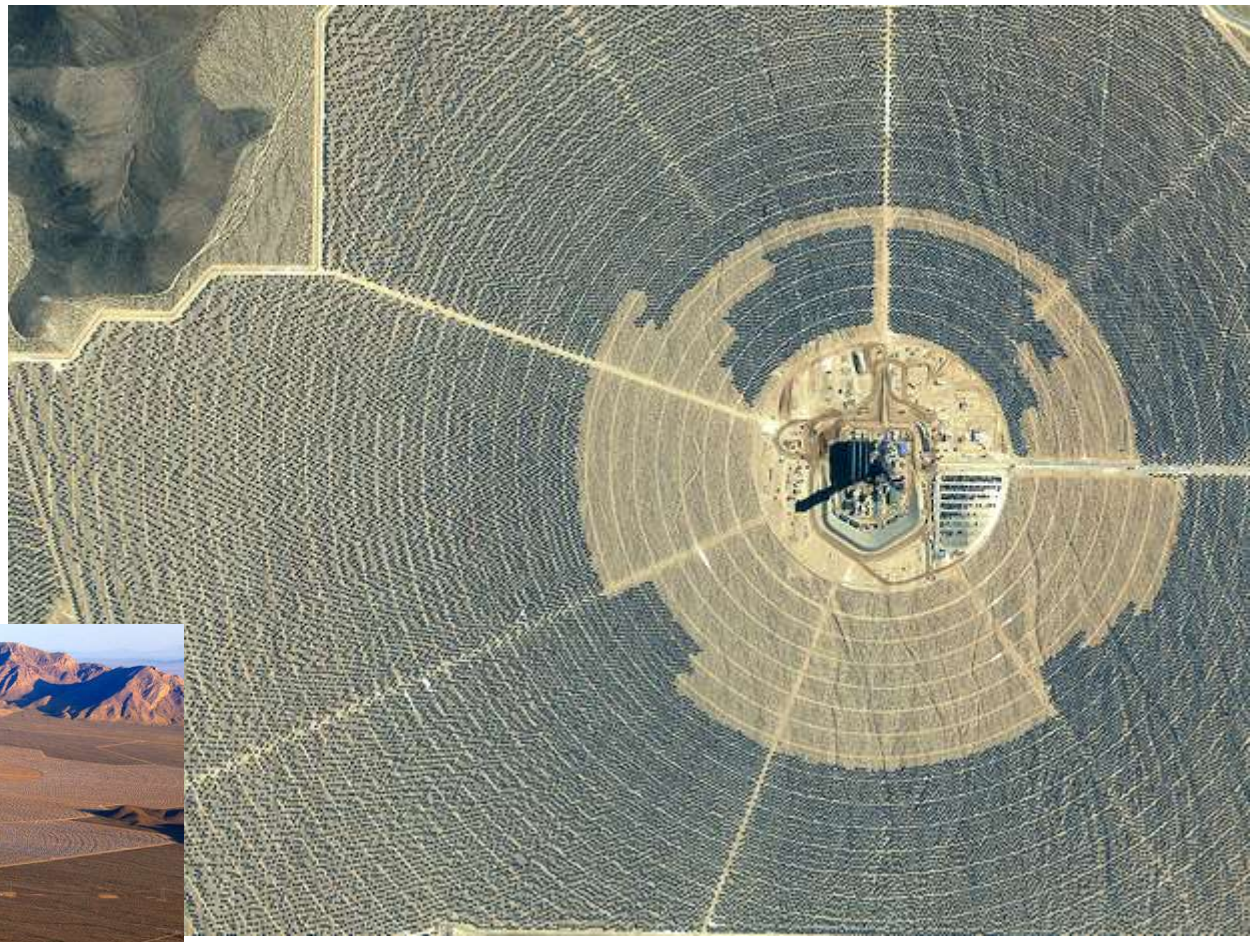
# European supergrid



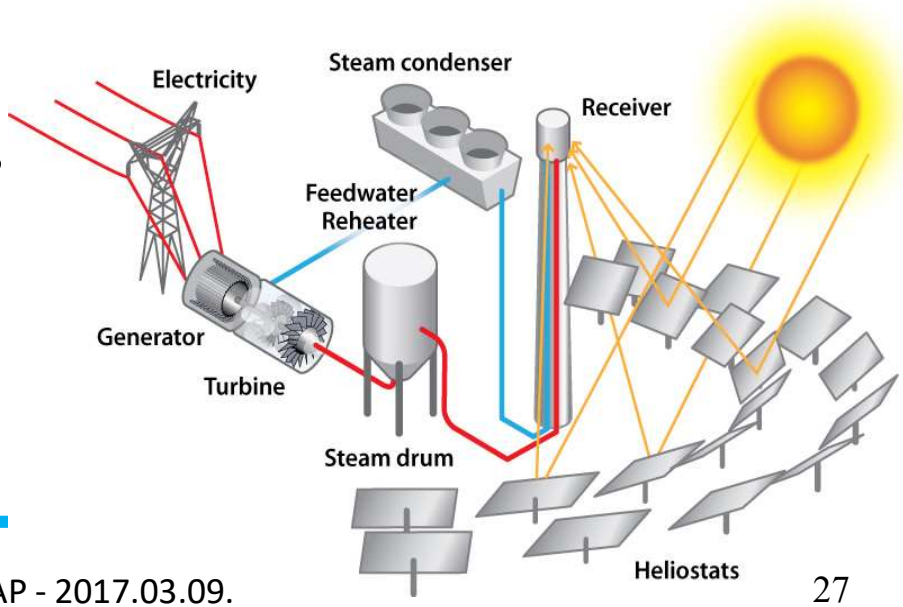



- Located in California, Mojave Desert
- $2.3 billion project (550 b HUF)
- World's largest CSP facility
- Generates 400 MW solar energy
- 14.2 square km total area

# Ivanpah, CA, 380 MW



- 347,000 heliostats (mirrors)
- 147-meter-tall towers
- Heated water system
- Standard turbine generators
- Air-cooled gas condensers



# Ivanpah



# Ivanpah

# Ivanpah

# Napkémény: Manzanares, Spanyolország

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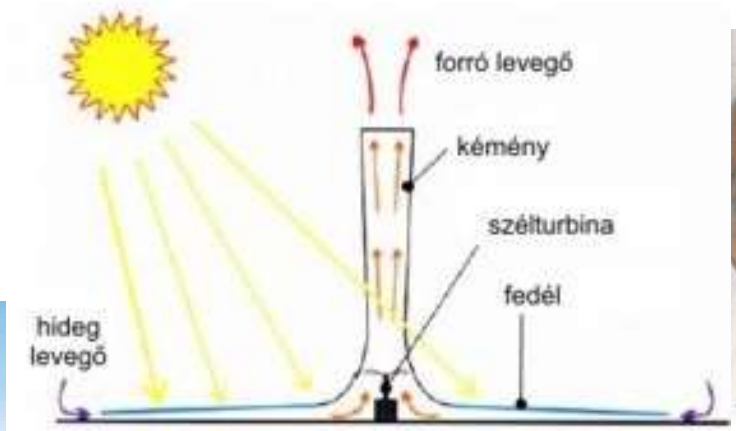
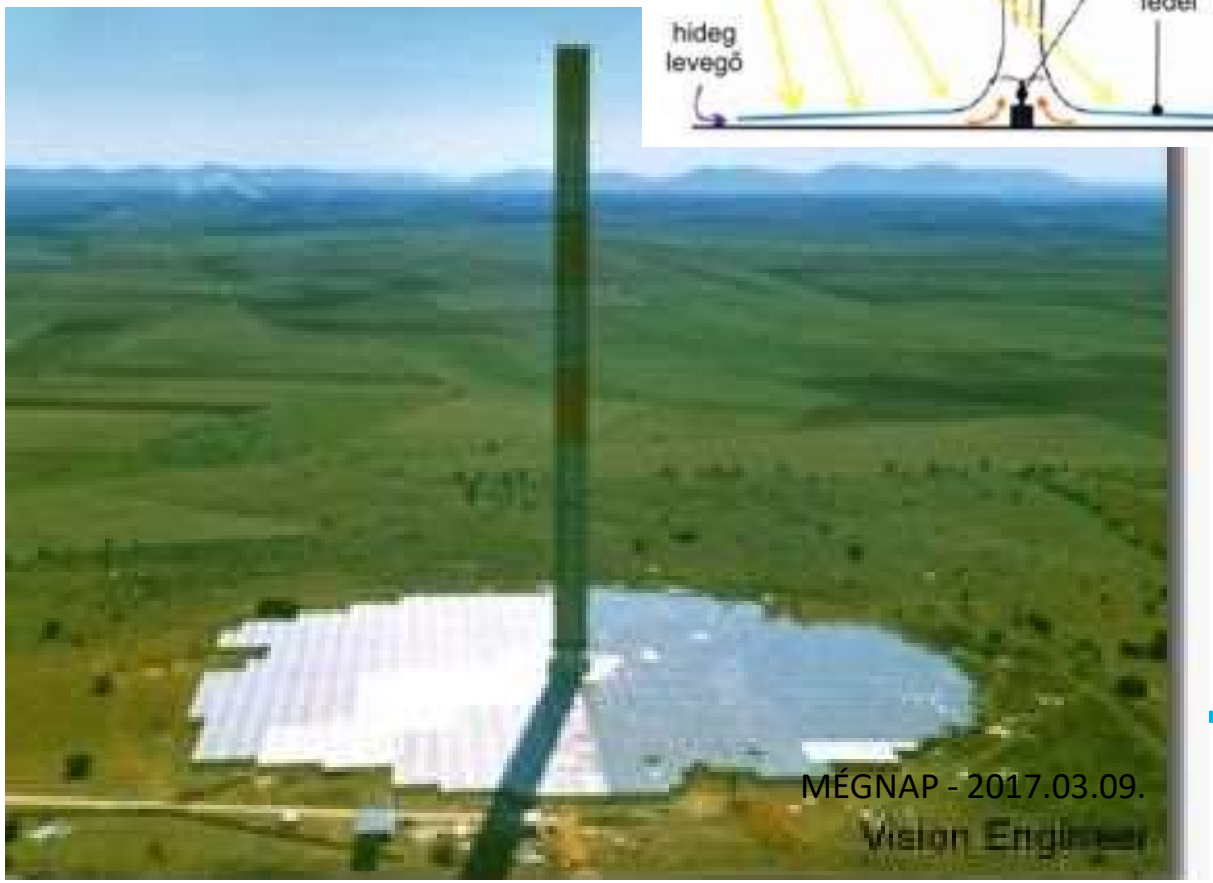


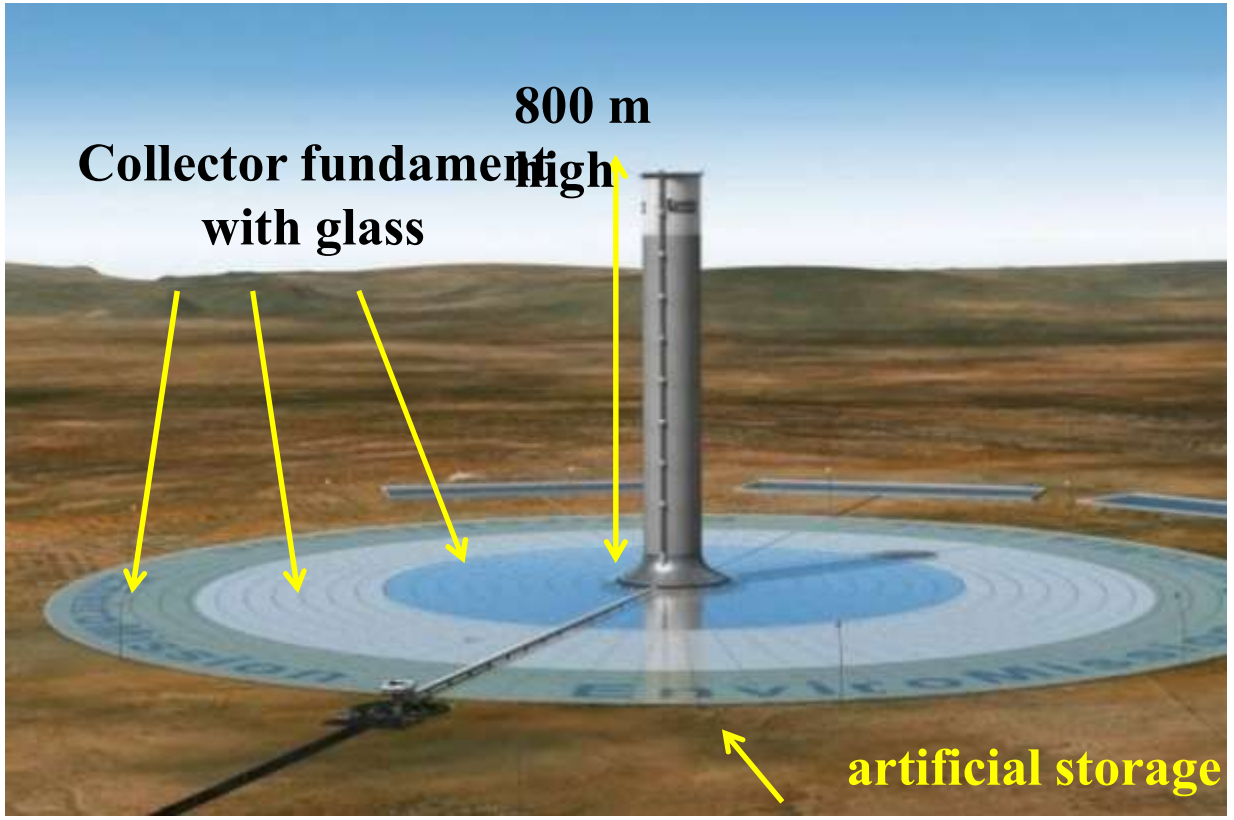





For about seven years, a 195-meter-tall (640-foot) chimney rose above the plain in Manzanares, Spain, south of Madrid. The solar updraft tower, which had turbines at its base, rose from the middle of a 46 000-square-meter greenhouse-like collection area; it generated up to 50 kilowatts of power—that is, until it fell over. The unfortunate end to the solar chimney is little more than a footnote. It failed due to supporting wires that weren't designed to resist corrosion

# Tervek a jövőből: Solar Updraft Tower

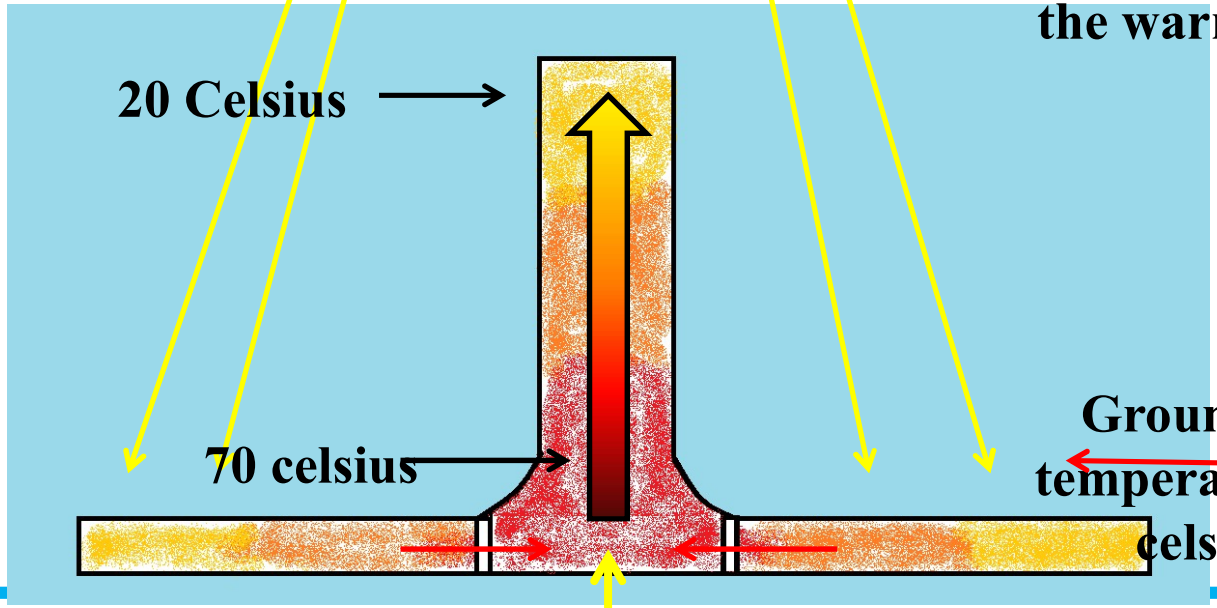
# How does it look like in practice



# Structure and operational scheme

**1.**
**The warm air want to escape because the ground air temperature is lower.**

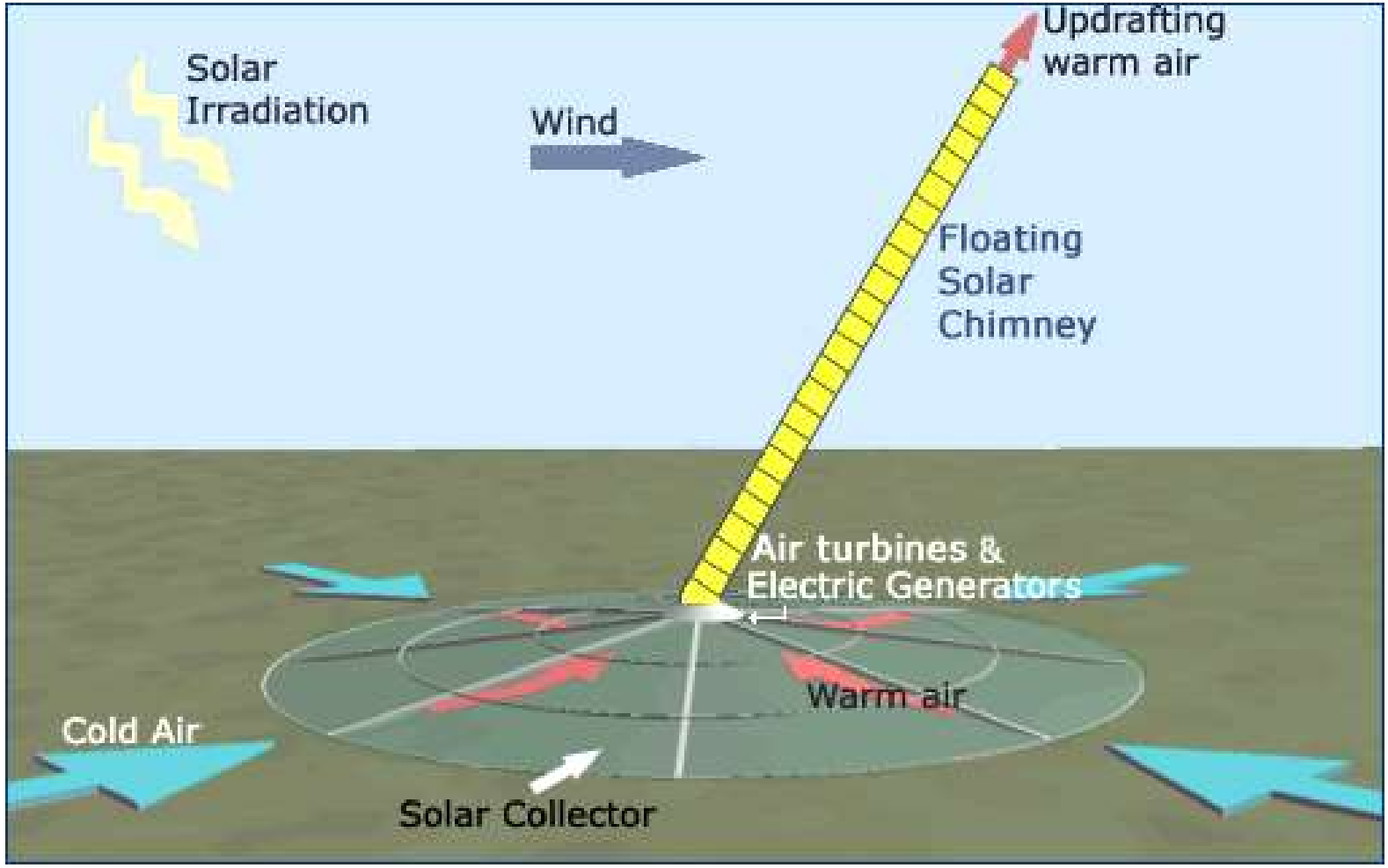
**2.**
**In the top of tower there is lower pressure and temperature and consequently it is develops drafts and this will absorb the warm air.**



# Floating chimney

http://www.greenoptimistic.com/the-tornado-solar-tower-get-power-from-recycled-heat-20080210/#.VVpM1Pl_tu4





# Size of some buildings compared to the Solar Chimneys projects in Spain, Australia, Namibia

http://www.solar-tower.org.uk/frequently-asked-questions.php

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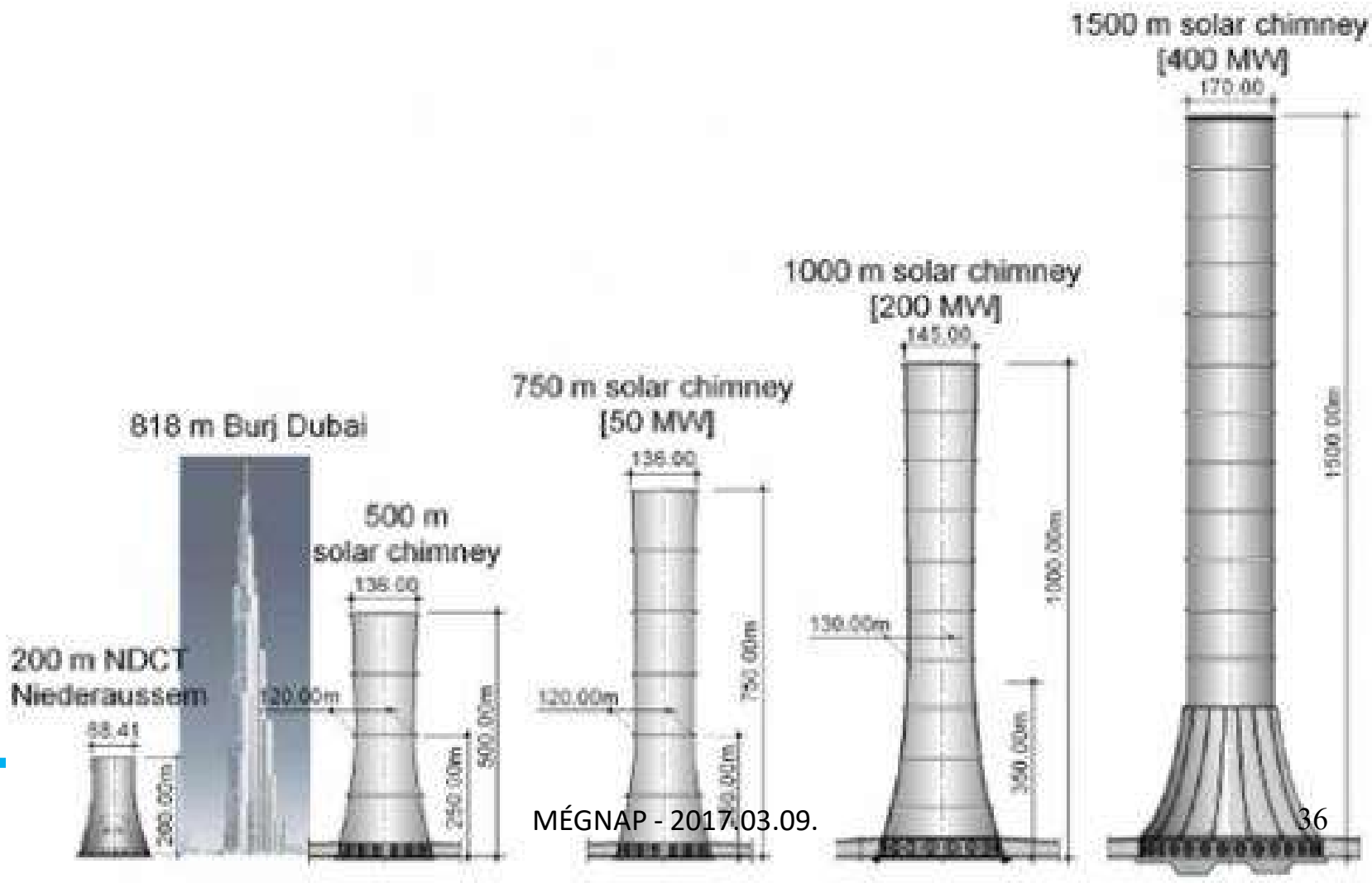
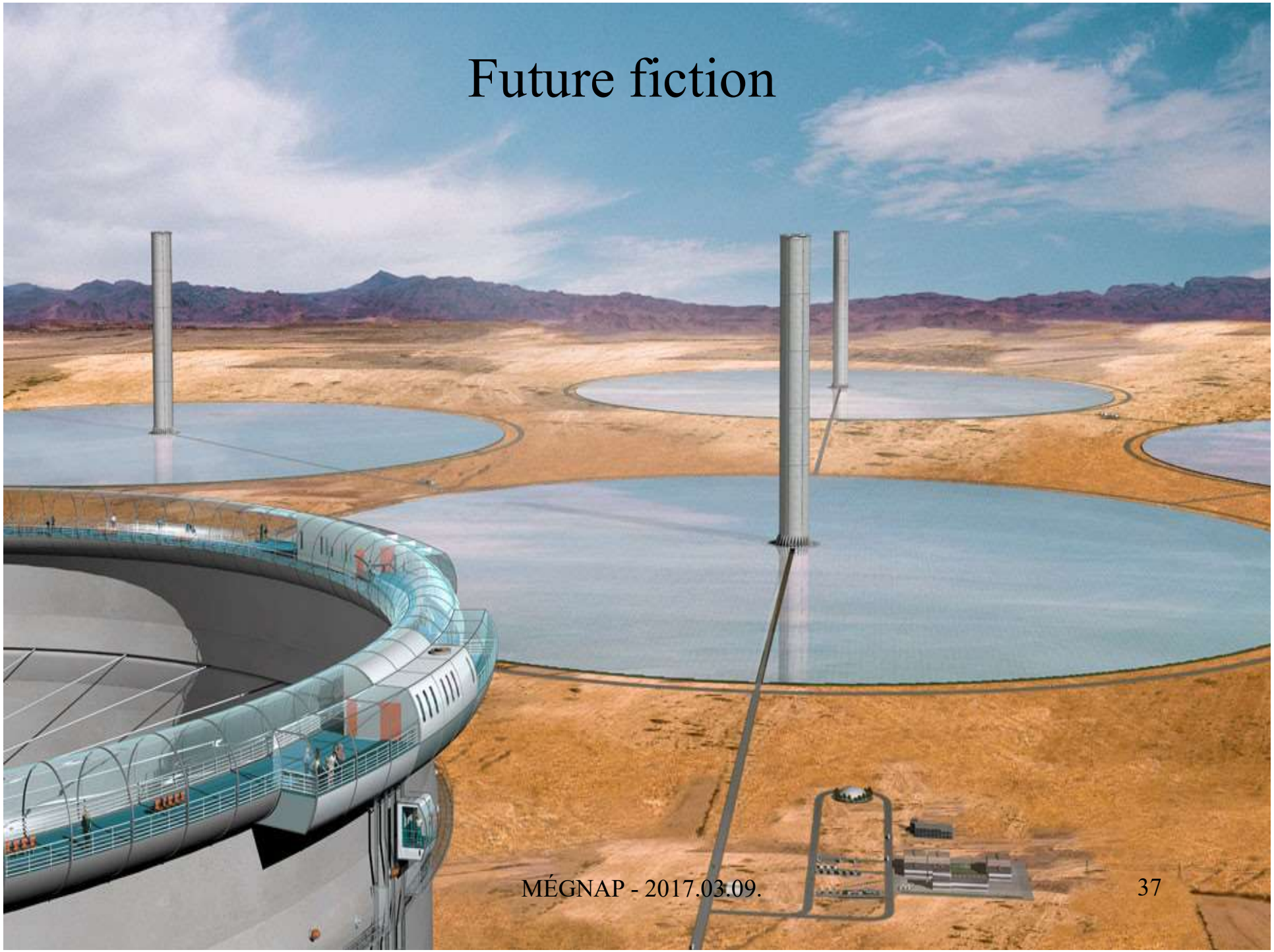
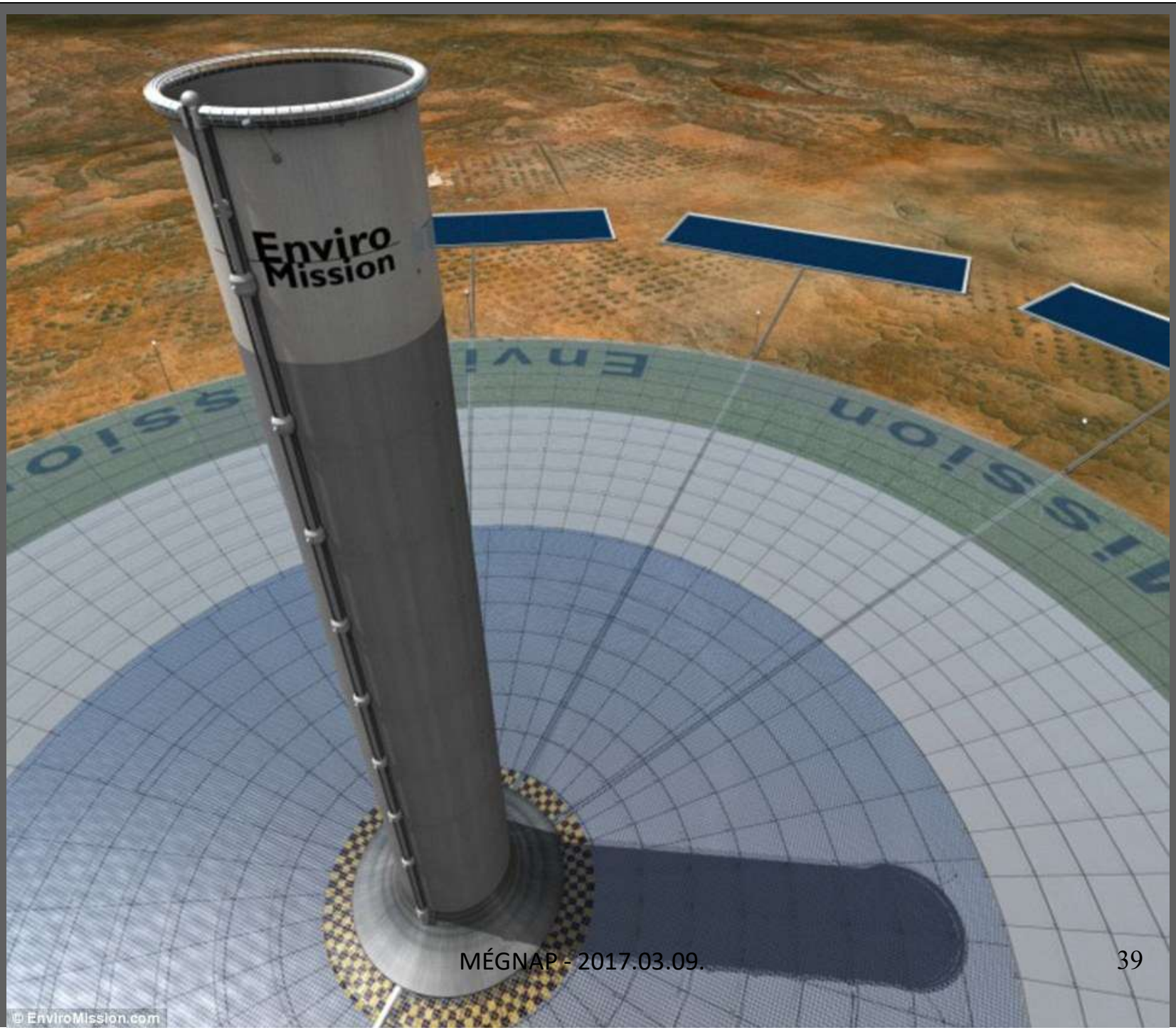


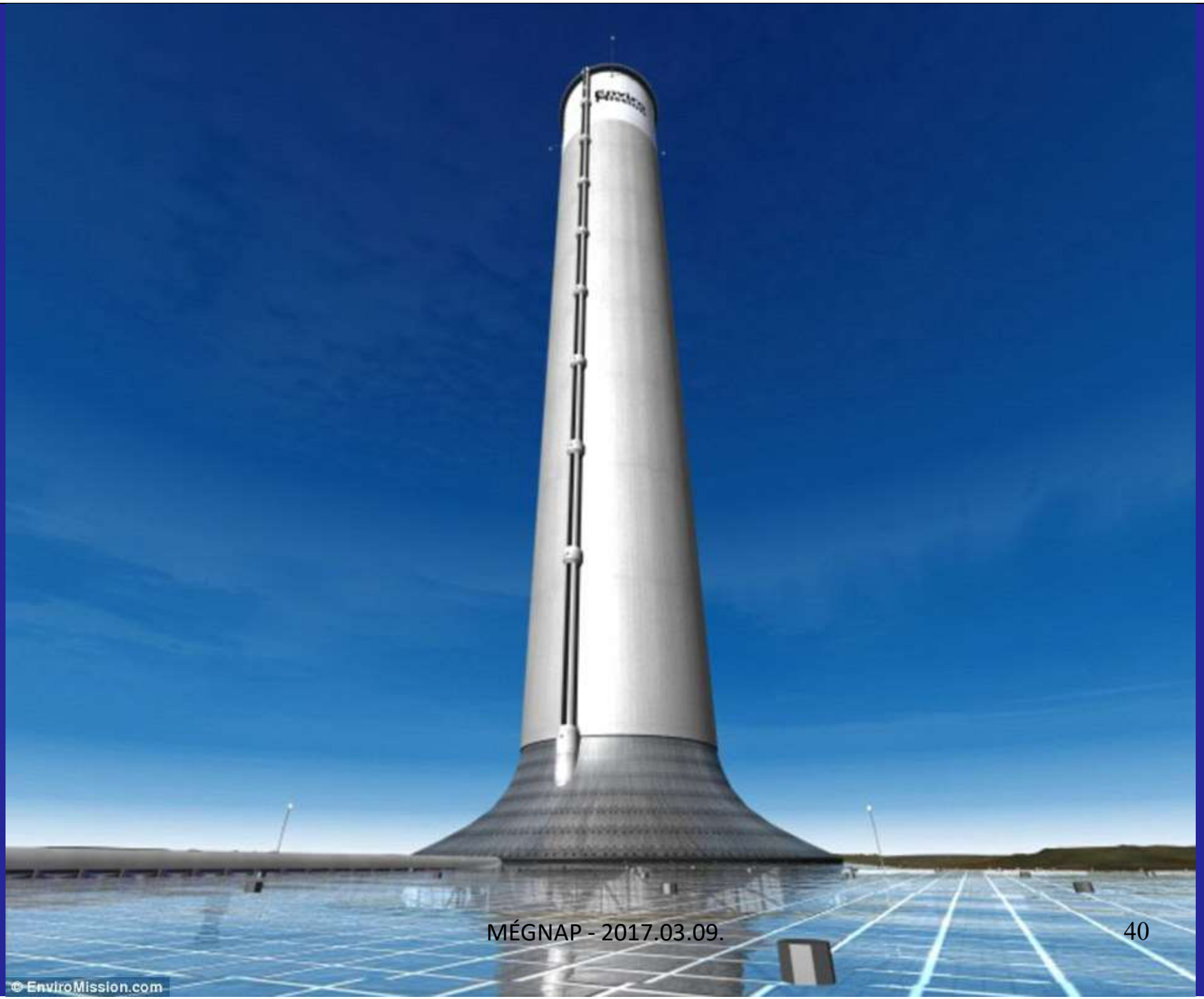
# Future fiction



# Solar power tower in Arizona

- $700million to build
- 2,600 foot chimney
- more than two miles in diameter
- one million megawatt hours /year
- 32 wind turbines, each rated at 6.25 MW, circling the base of the tower


Enviro
Mission
© EnviroMission.com

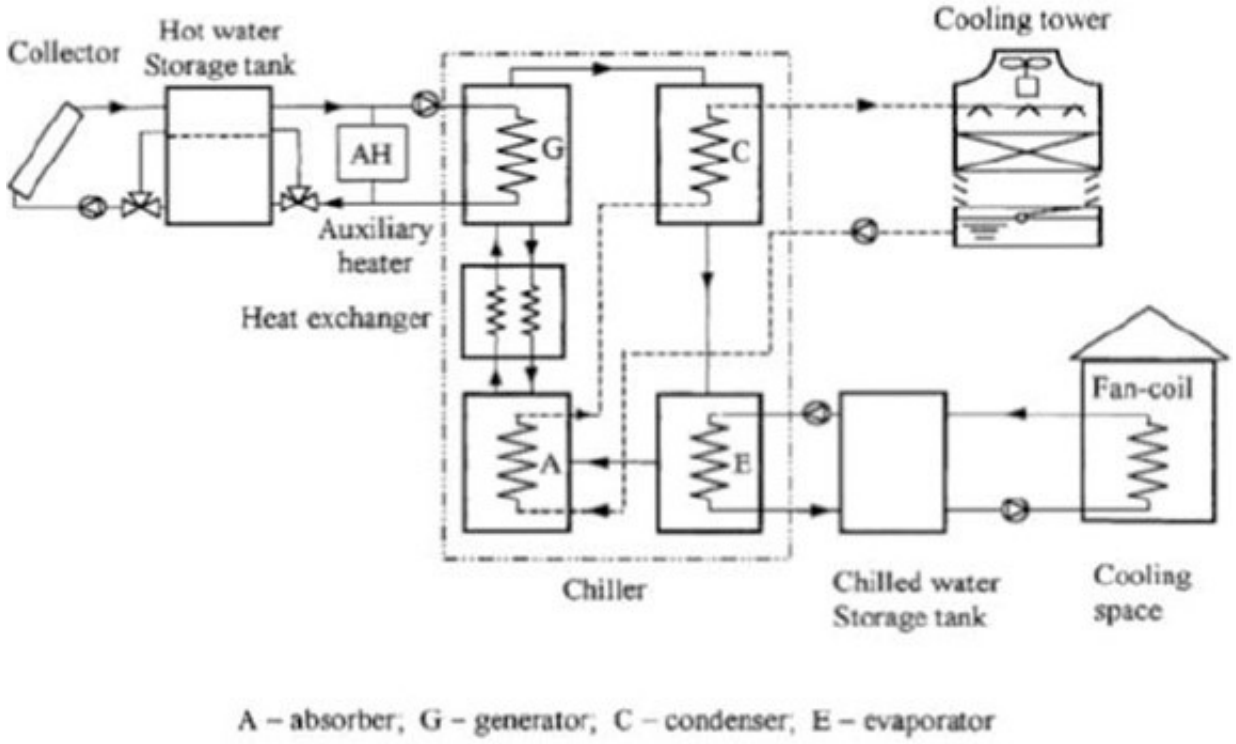

© EnviroMission.com

# Chinese solar tower

http://www.scmp.com/news/china/article/1487659/solar-chimneys-may-help-solve-chinas-energy-woes

- A test updraft tower in Inner Mongolia could only be built to 50 metres, not the desired 200, because of a nearby airport.
- Starting operation on Dec 10, the 200-kilowatt power generating unit can supply 400,000 kW

# Solar cooling I.

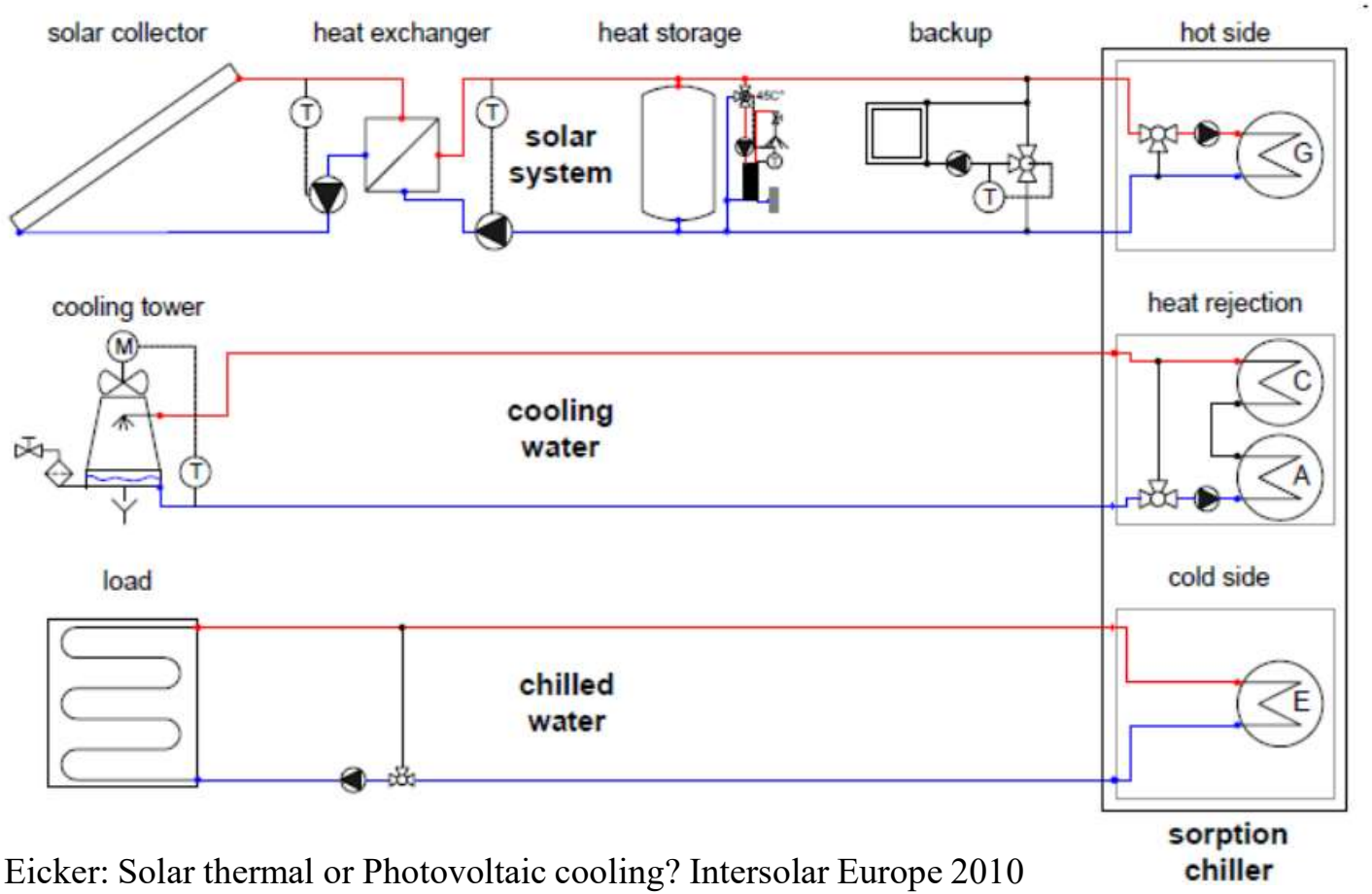



A – absorber; G – generator; C – condenser; E – evaporator

The LiBr-water absorption cycle has the working pair fluid of LiBr (absorbent) and water (refrigerant)

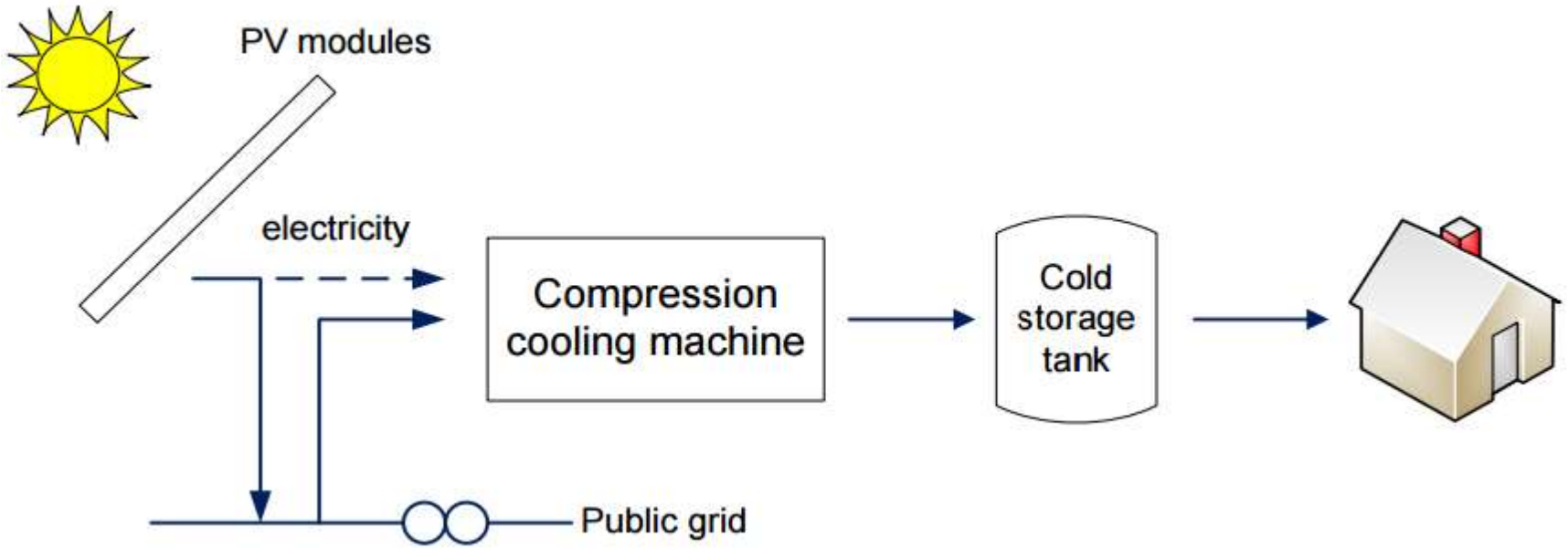
Tatenda J Bvumbe; Freddie L Inambao: Operational evaluation of the performance of a solar powered absorption system in Pretoria; Journal of Energy in Southern Africa vol.24 n.3 Cape Town Jan. 2013

# Solar cooling I.




Ursula Eicker: Solar thermal or Photovoltaic cooling? Intersolar Europe 2010

# Solar cooling II?




Ursula Eicker: Solar thermal or Photovoltaic cooling? Intersolar Europe 2010

# Solar thermal+PV Dunakeszi, 2009, TESCO

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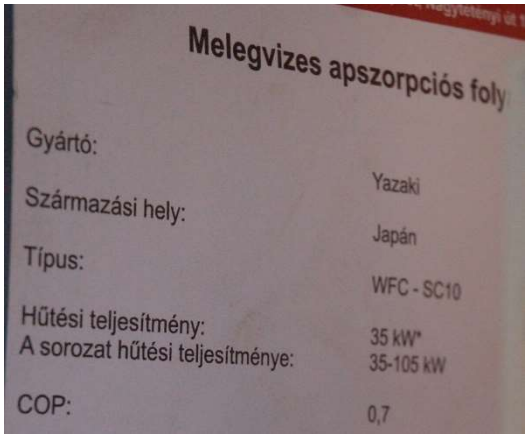


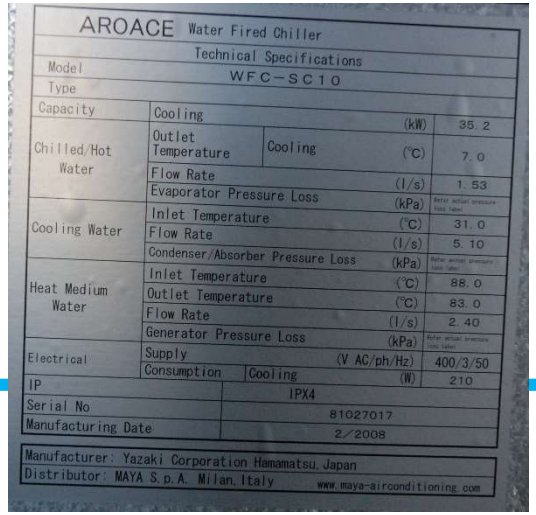


# HYBRID MICROGRIDS: DIESEL - STORAGE – RENEWABLE

Francois-Xavier Saury - Caterpillar Inc. - February 2016

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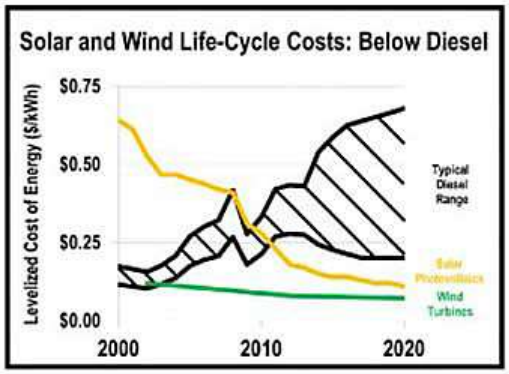
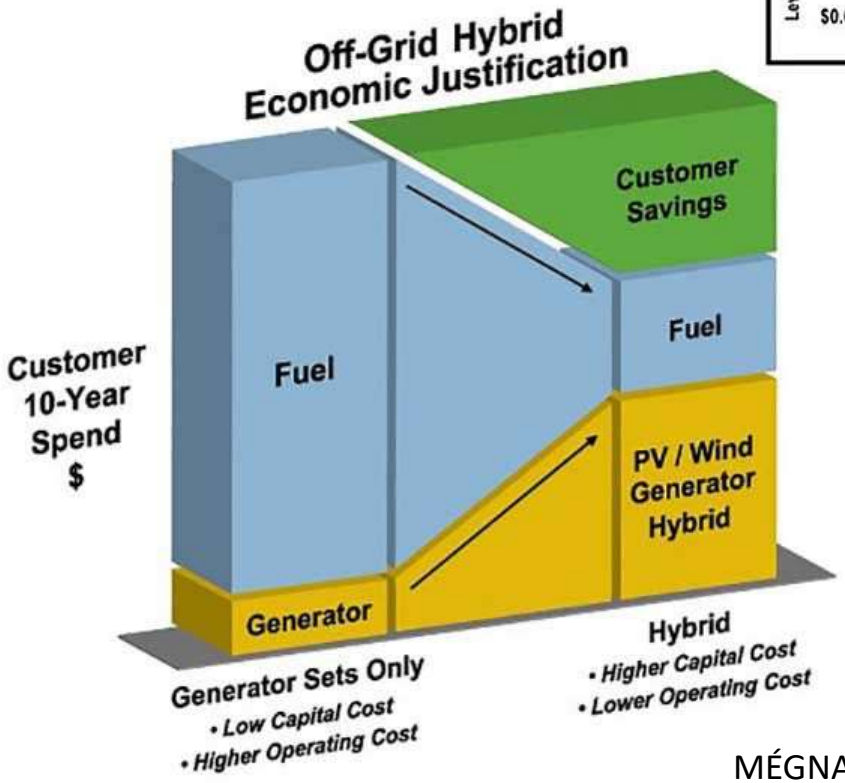
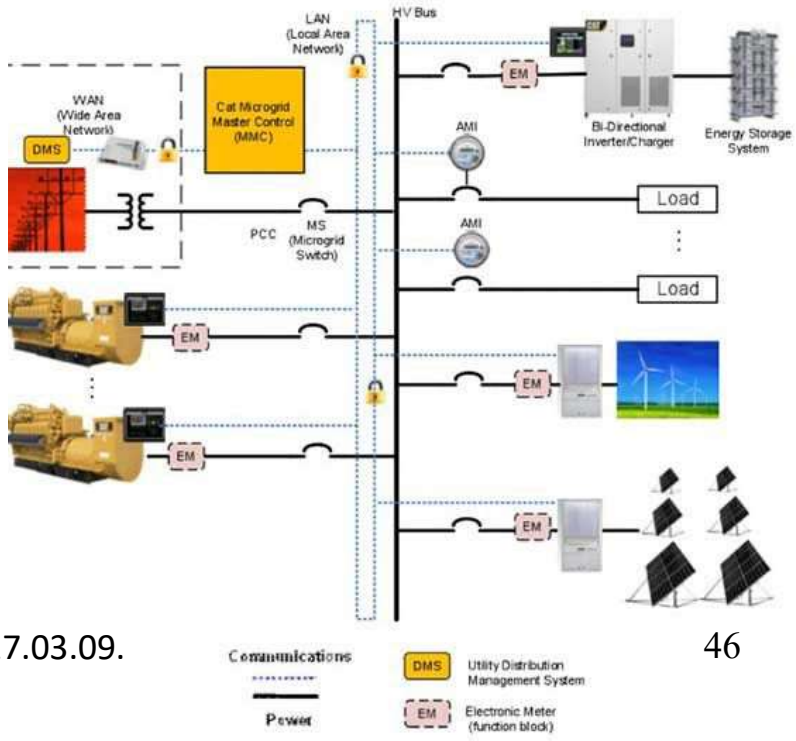
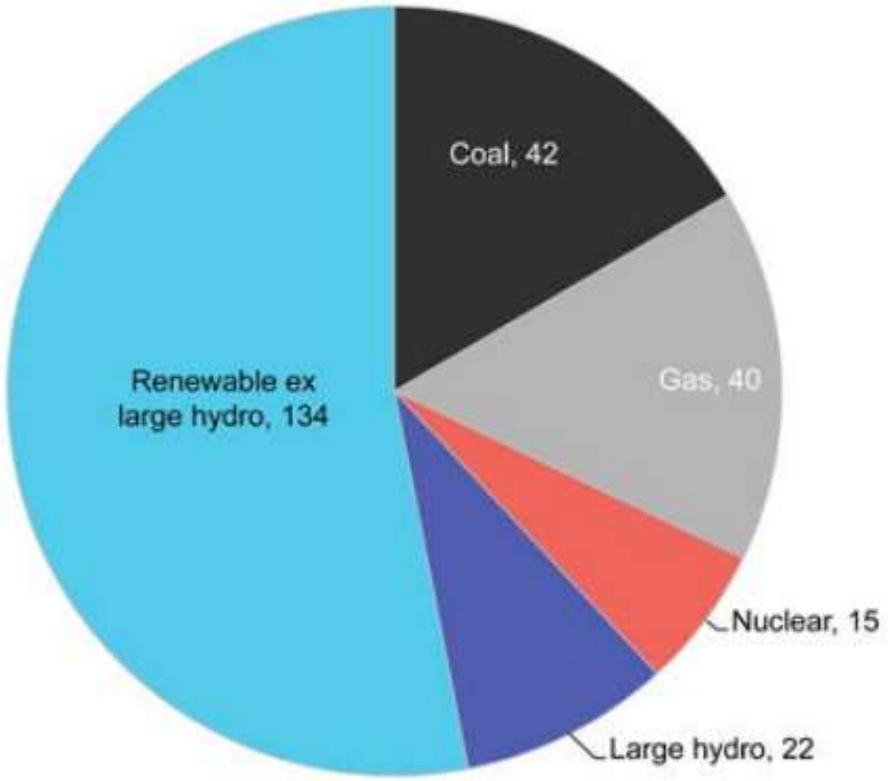


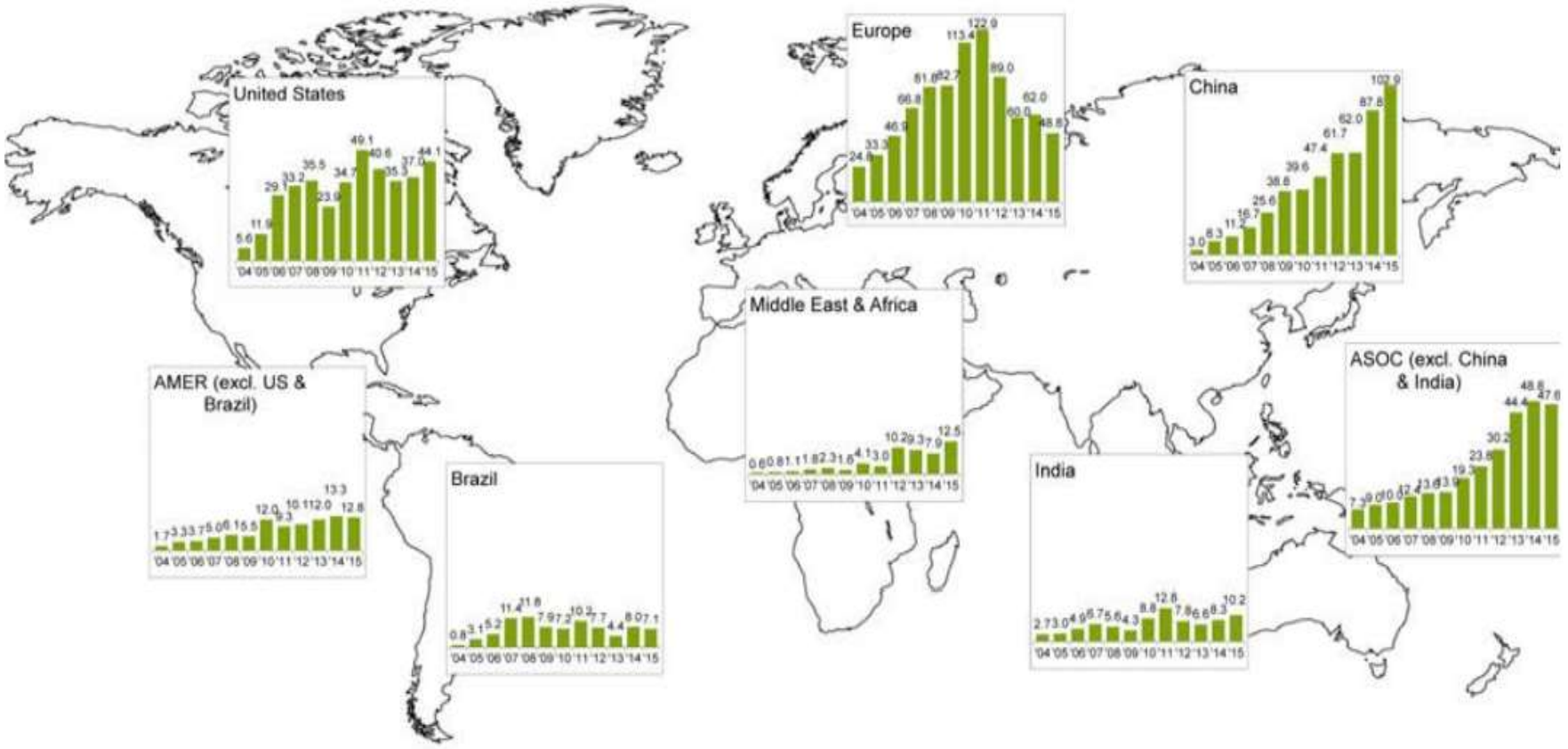
# 2015-ben csatlakoztatott új kapacitások




Source: Bloomberg New Energy Finance

# Megújuló beruházások 2004-2015






Source: Bloomberg New Energy Finance

# Beruházási arányok 2015-ben

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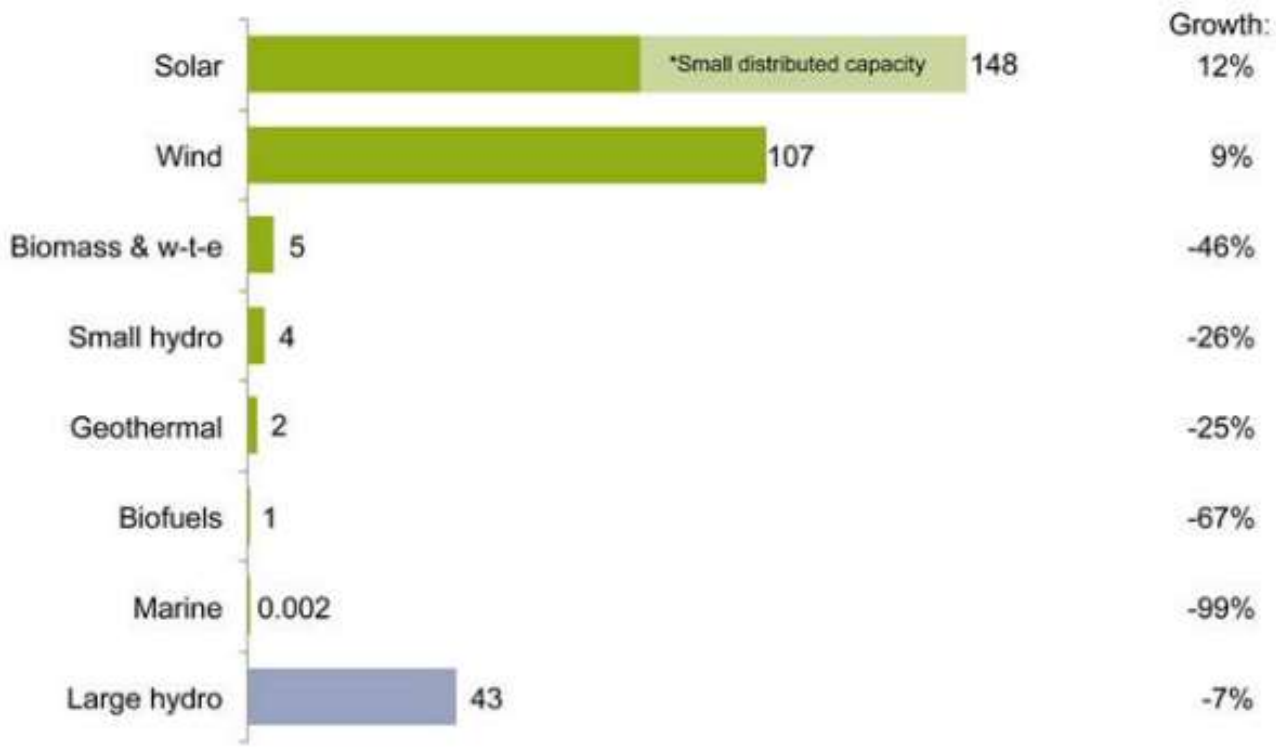


Source: Bloomberg New Energy Finance

# Az energiaárak alakulása 1980 óta, a fosszilis energiahordozókhoz viszonyítva

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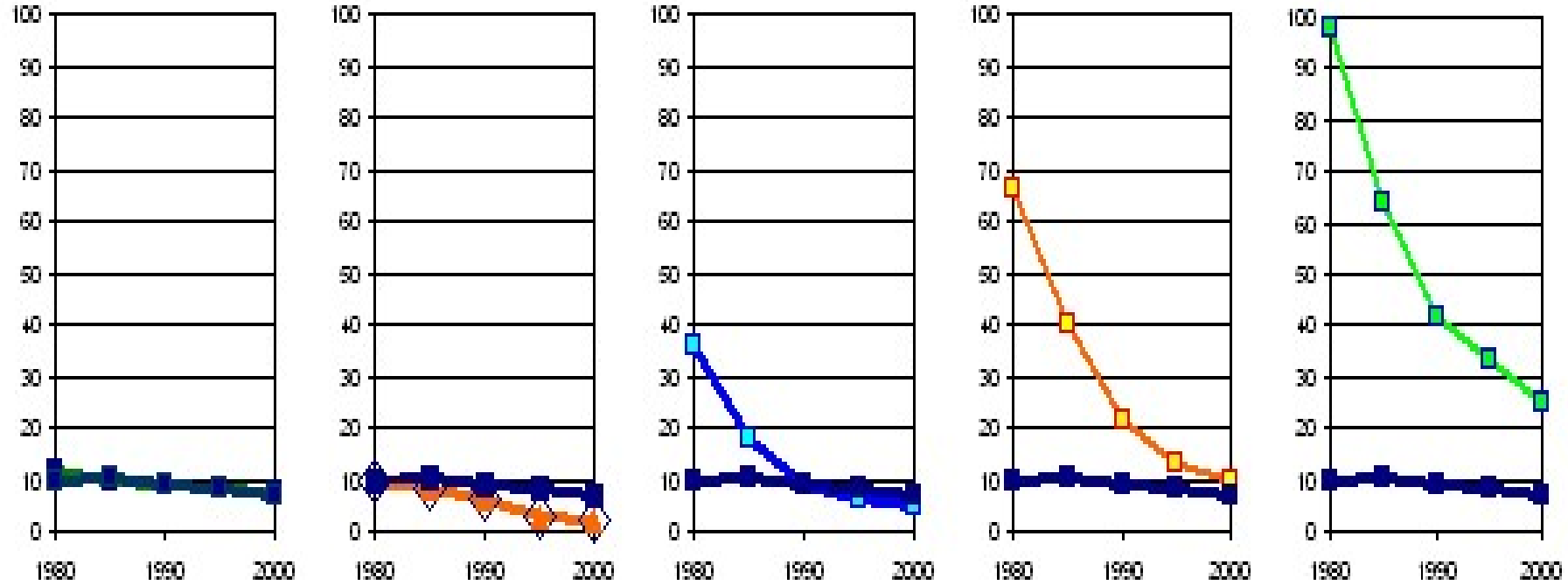

# Áresés

- Cellaköltség tizedelődés az utóbbi évtizedben
- LCOE költségek
- Energia piaci költség
  - $20/MWh bid in reach as tenders grow more competitive across global markets
  - In 2016, the Abu Dhabi Water & Electricity Authority (ADWEA) announced a $24/MWh solar bid

# 1 W-nyi napelem cella végfelhasználói árának változása

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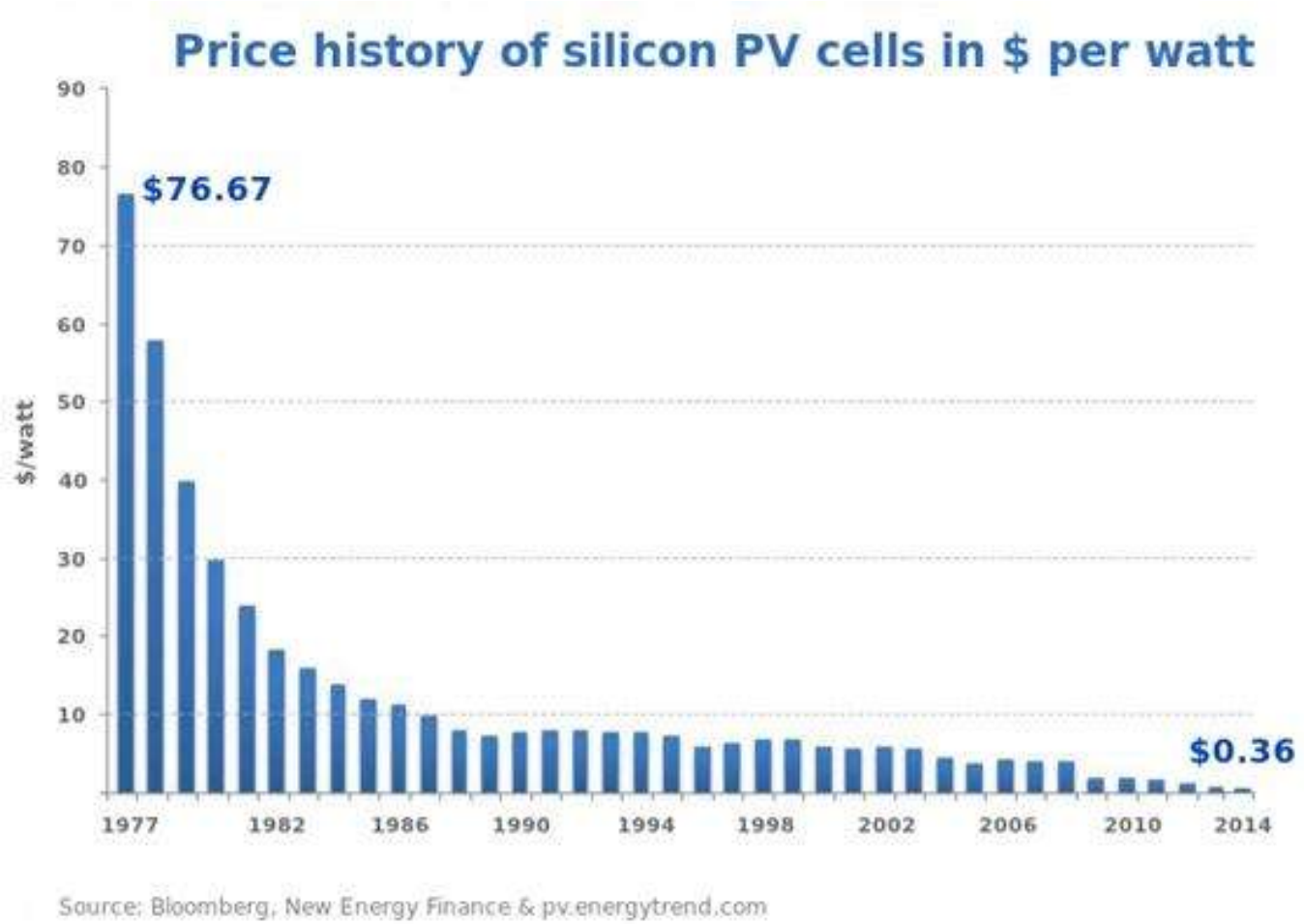

# Estimated LCOE for new generation resources, for plants entering service in 2022

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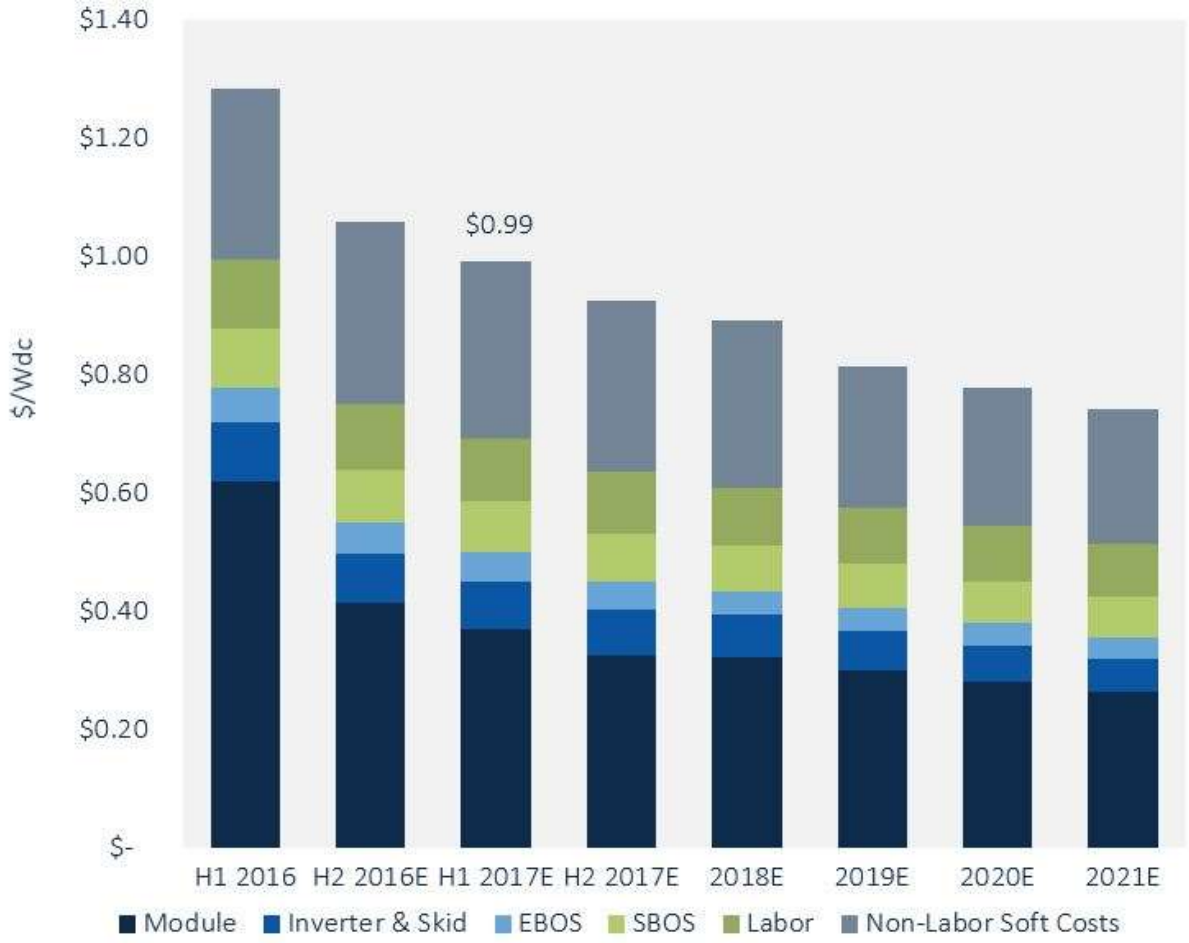
**U.S. Average LCOE (2015 $/MWh) for Plants Entering Service in 2022**

| Plant Type | Capacity Factor (%) | Levelized Capital Cost | Fixed O&M | Variable O&M (including fuel) | Transmission Investment | Total System LCOE | Levelized Tax Credit | Total LCOE including Tax Credit[1] |
|---|---|---|---|---|---|---|---|---|
| **Dispatchable Technologies** | | | | | | | | |
| Advanced Coal with CCS[2] | 85 | 97.2 | 9.2 | 31.9 | 1.2 | 139.5 | N/A | 139.5 |
| Natural Gas-fired | | | | | | | | |
| Conventional Combined Cycle | 87 | 13.9 | 1.4 | 41.5 | 1.2 | 58.1 | N/A | 58.1 |
| Advanced Combined Cycle | 87 | 15.8 | 1.3 | 38.9 | 1.2 | 57.2 | N/A | 57.2 |
| Advanced CC with CCS | 87 | 29.2 | 4.3 | 50.1 | 1.2 | 84.8 | N/A | 84.8 |
| Conventional Combustion Turbine | 30 | 40.9 | 6.5 | 59.9 | 3.4 | 110.8 | N/A | 110.8 |
| Advanced Combustion Turbine | 30 | 25.8 | 2.5 | 63.0 | 3.4 | 94.7 | N/A | 94.7 |
| Advanced Nuclear | 90 | 78.0 | 12.4 | 11.3 | 1.1 | 102.8 | N/A | 102.8 |
| Geothermal | 91 | 30.9 | 12.6 | 0.0 | 1.4 | 45.0 | -3.1 | 41.9 |
| Biomass | 83 | 44.9 | 14.9 | 35.0 | 1.2 | 96.1 | N/A | 96.1 |
| **Non-Dispatchable Technologies** | | | | | | | | |
| Wind | 40 | 48.5 | 13.2 | 0.0 | 2.8 | 64.5 | -7.6 | 56.9 |
| Wind – Offshore | 45 | 134.0 | 19.3 | 0.0 | 4.8 | 158.1 | -11.4 | 146.7 |
| Solar PV[3] | 25 | 70.7 | 9.9 | 0.0 | 4.1 | 84.7 | -18.4 | 66.3 |
| Solar Thermal | 20 | 186.6 | 43.3 | 0.0 | 6.0 | 235.9 | -56.0 | 179.9 |
| Hydroelectric[4] | 58 | 57.5 | 3.6 | 4.9 | 1.9 | 67.8 | N/A | 67.8 |

Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2016; U.S. Energy Information Administration | AEO2016 Levelized Costs

# U.S. Utility PV Fixed-Tilt Turnkey EPC System Pricing, H1 2016-2021E ($/Wdc) 1 USD alatt!

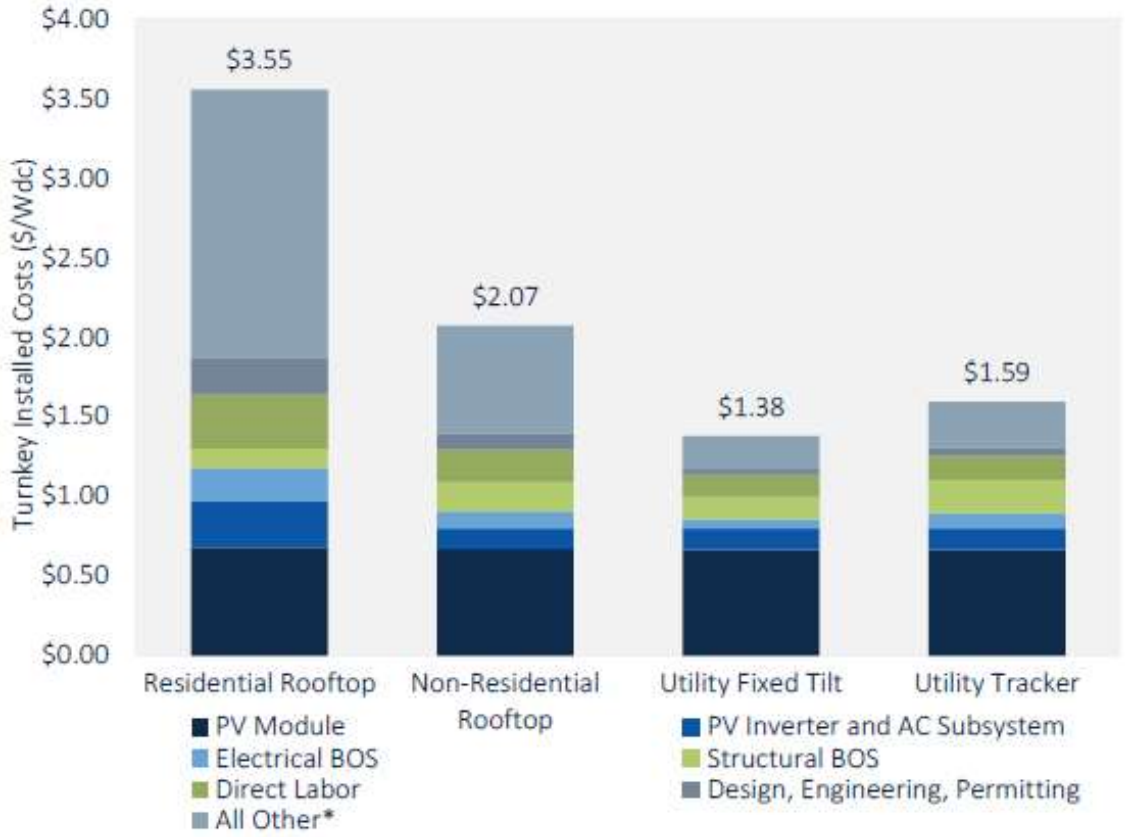





*Source:* GTM Research / SEIA U.S. Solar Market Insight

# Average U.S. System Cost Breakdown by Market Segment, Q3 2015

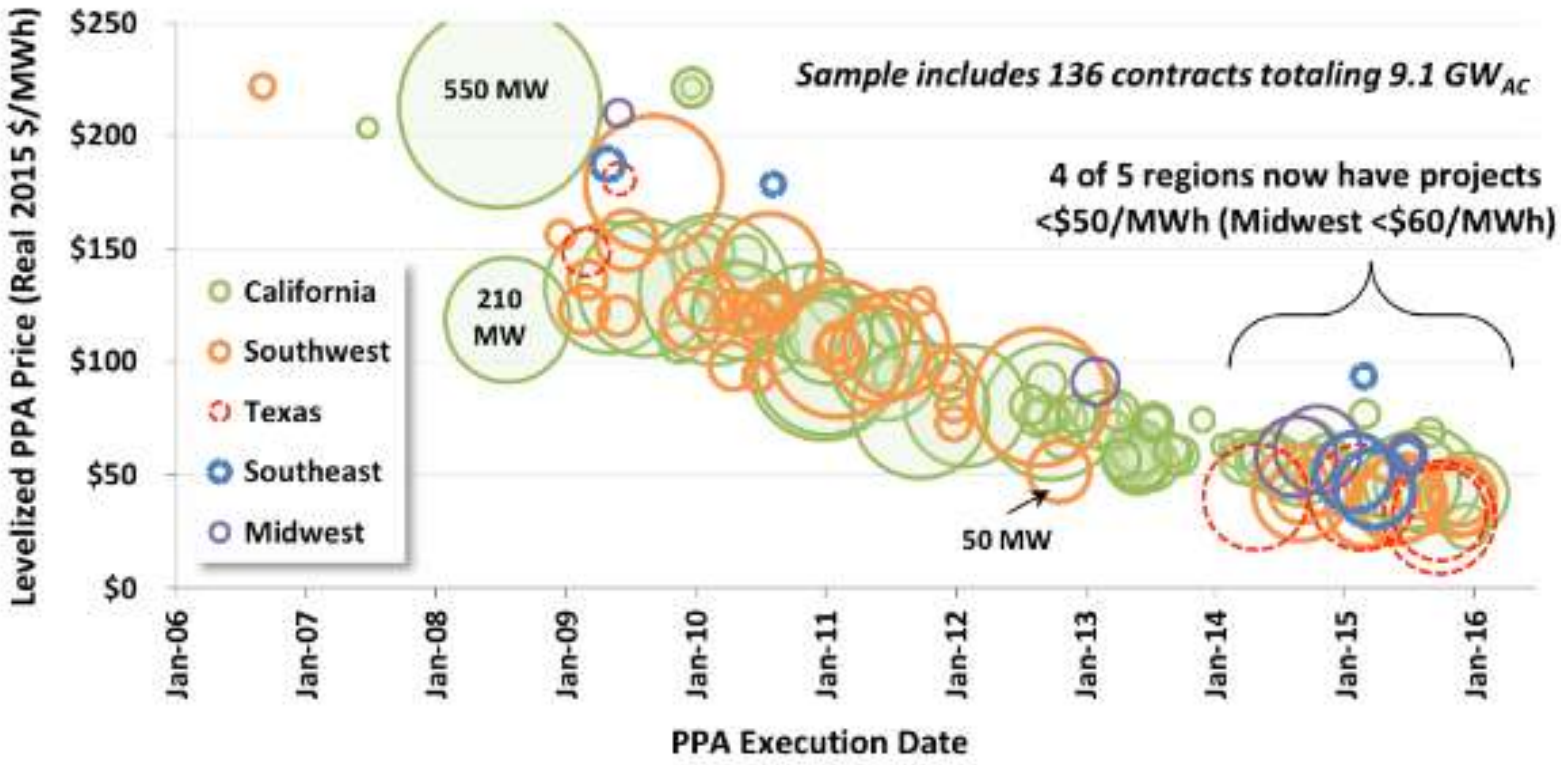





*Source:* GTM Research / SEIA U.S. Solar Market Insight

# The price paid for long-term solar power purchase agreement (PPA) contracts in 2015






Robert Fares on August 27, 2016

# Price-Competitiveness Increasing in Tenders Globally, Q2 2015-Q4 2016

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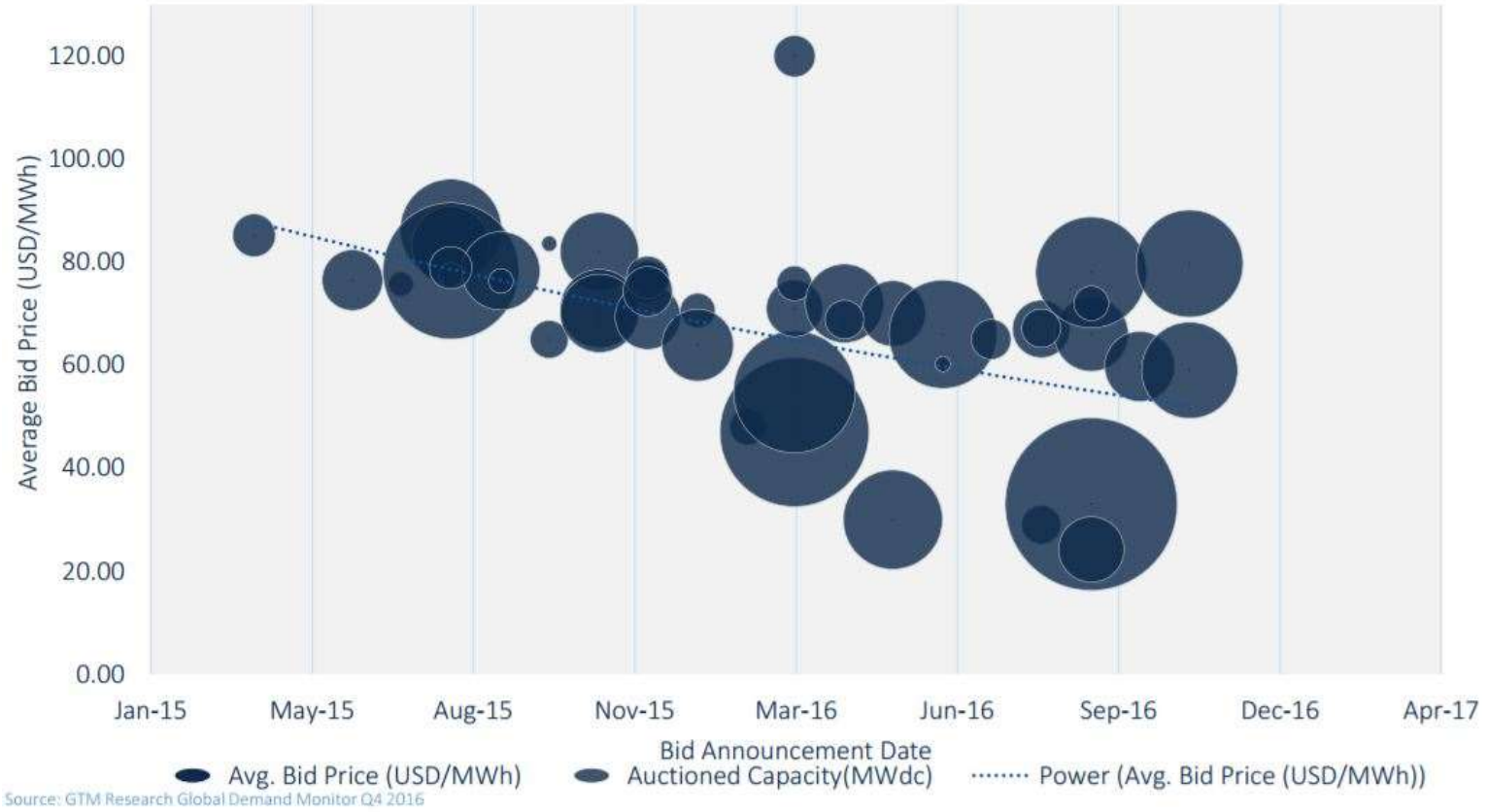
Villamosenergetikai Intézet
Alternatív Energiaforrások
Tudásközpont

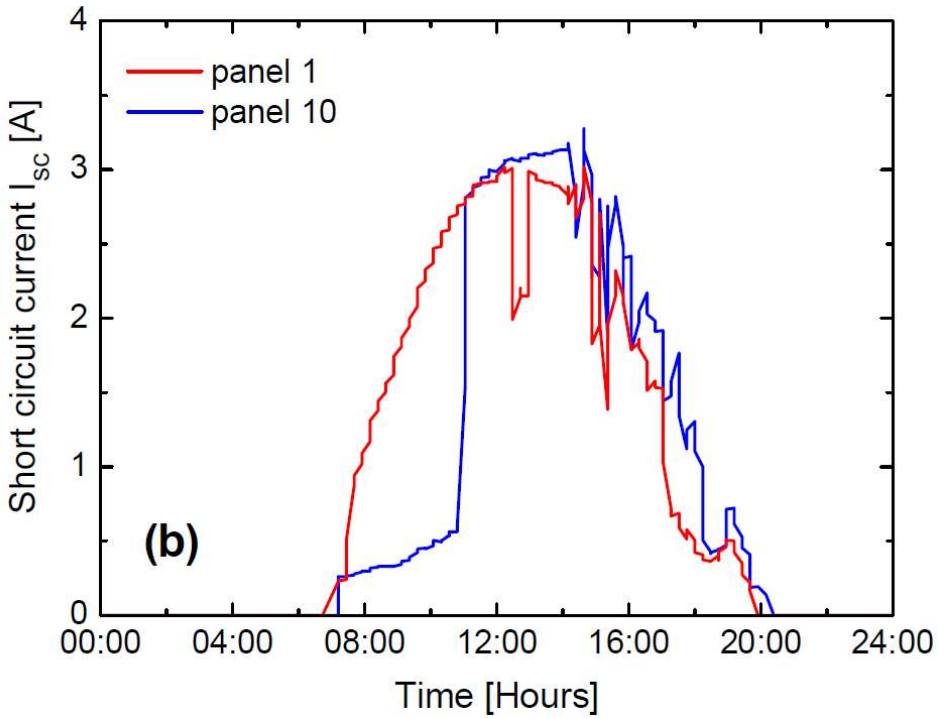


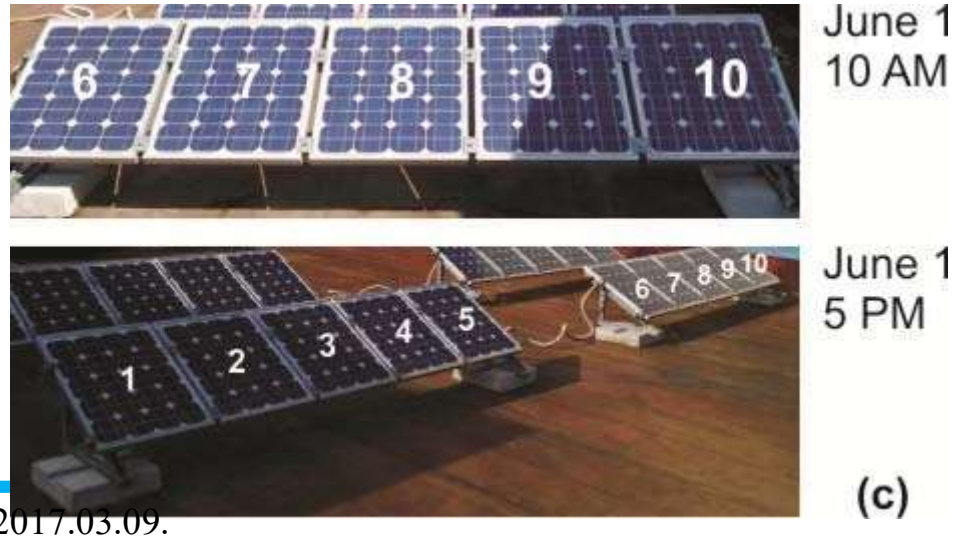
# String vagy központi inverter?

- Méretgazdaságosság? Inverter hatásfok?

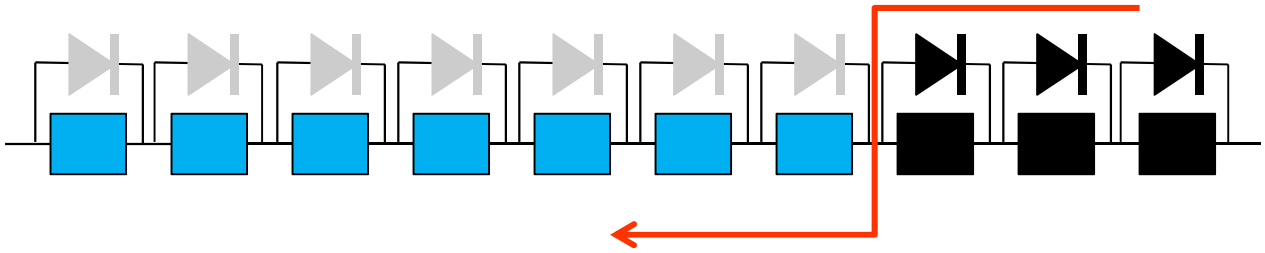
# Partial shading effect – részleges árnyékolás





# (Passive) Bypass diodes



# New trends

http://rencd-media.com/portal/unsubscribeconfirm/?cFxPrV9clf%2FF3KlcYpqm7HE%2BZ9lZawllA

## Smart Modules:
## The Next Generation of Solar

As the price of PV continues to drop, solar energy becomes an attainable reality for more and more homeowners, businesses and investors. However, despite compelling economics, some potential buyers are ineligible for solar due to insufficient space or too much **shading**. Enter smart modules: featuring embedded intelligence, these modules increase system flexibility, so buildings once considered inhospitable to solar can now accommodate a high-performing system. Smart modules also raise performance, increase monitoring capabilities and reduce safety risks. In short, smart modules are proving to be the next generation of solar.

# Effective Real-Time Performance Monitoring and Diagnostics of Individual Panels in PV Plants

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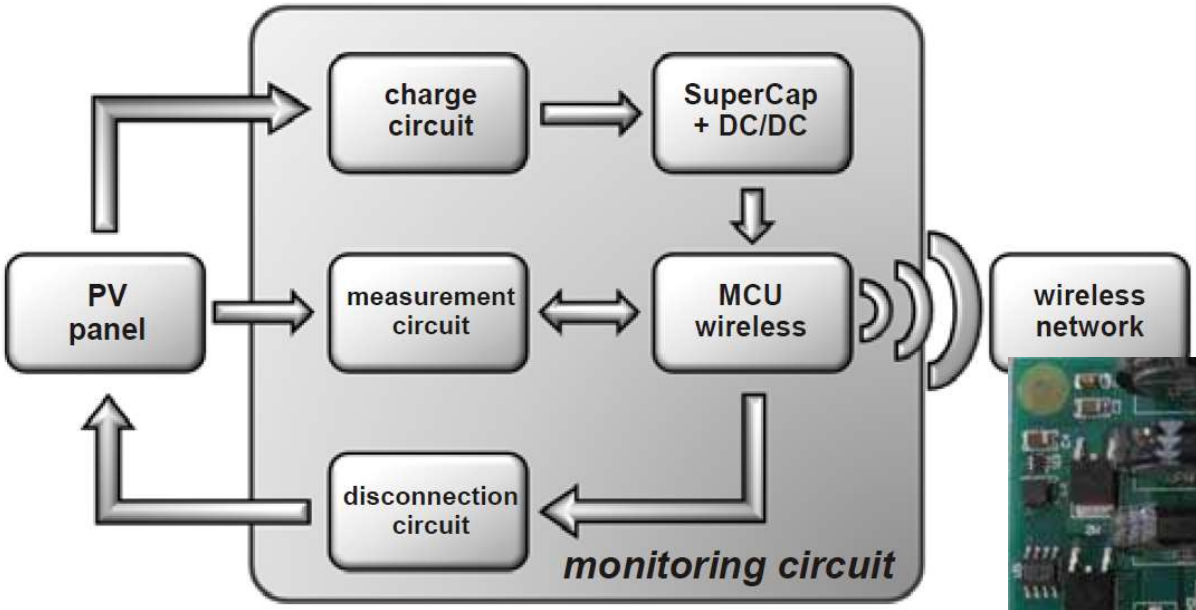
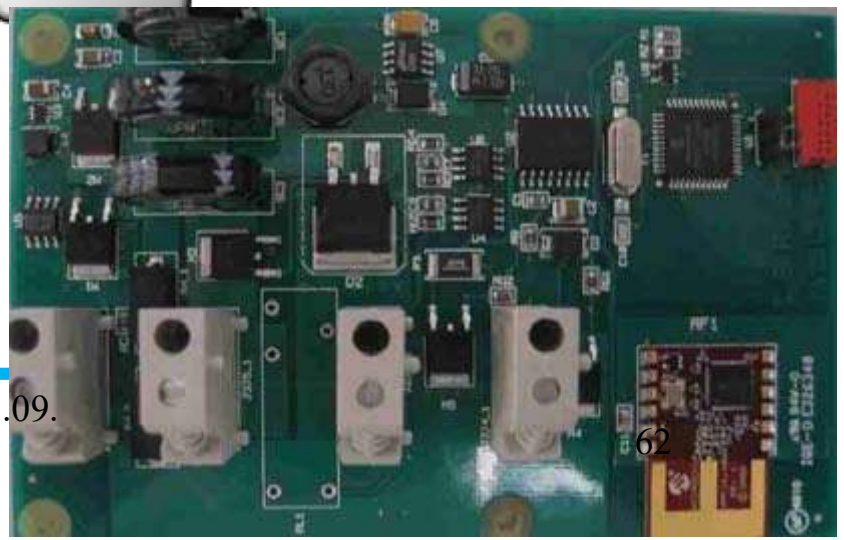
P. Guerriero*, V. d'Alessandro*, L. Petrazzuoli**, G. Vallone**, and S. Daliento*



# String inverter helyett Modul inverter!

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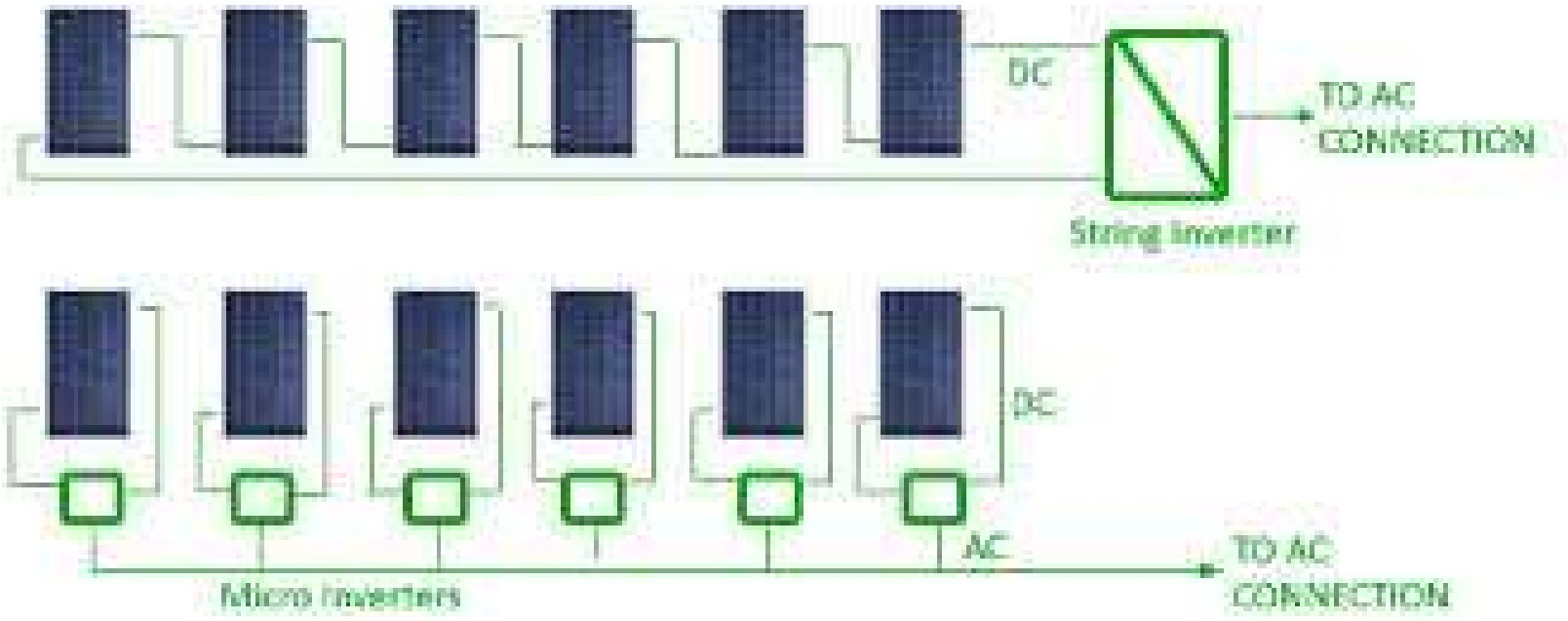
Tudásközpont



# Smart panel

- power optimizer panel-level maximum power point tracking

# Per-module Maximum Power Point Tracking (MPPT)

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Cover with Power Optimizer

Fixed Base

Bypass Connector

Cover for Standard Junction Box

# Az inverterek új szerepe

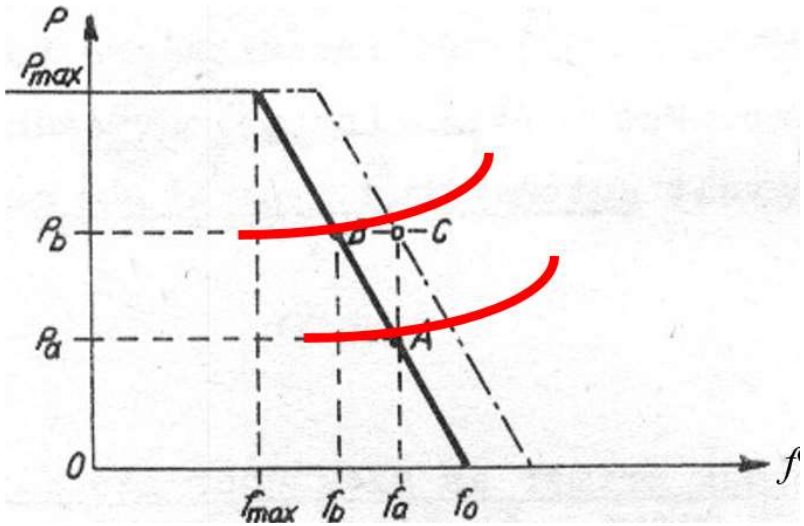
Hagyományosan

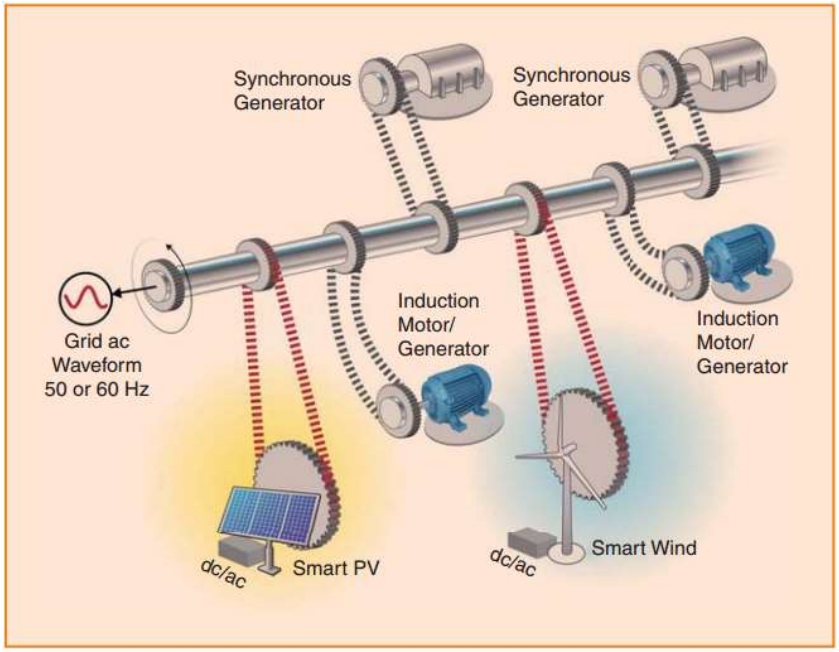
- DC -> AC
- MPPT
- Szinkronizálás
- Védelem

Új szerep

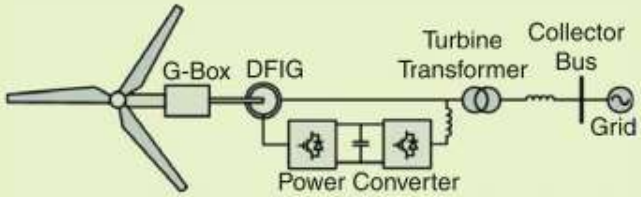
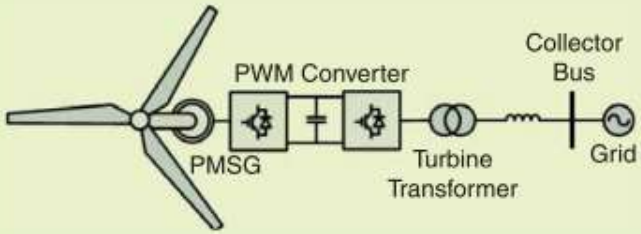
- Részvétel a primer szabályozásban

# Részvétel a rendszerszabályozásban



# Betáplálási „szerepek”

| Generation Type | Inertia | Active Power Control | Reactive Power, Voltage Control | Fault Ride-Through |
|---|---|---|---|---|
| Conventional synchronous generation  | √ | √ | √ | |
| DFIG wind turbine generator with partial power conversion   | √* | √ | √ | √ |
| Wind turbine generator with full-size power conversion   | √* | √ | √ | √ |

IEEE Power and Energy Magazine, March, 2017

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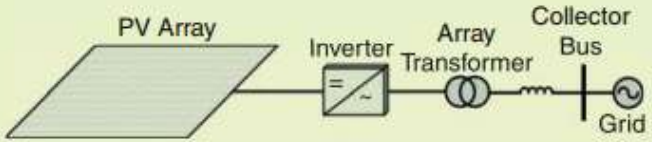
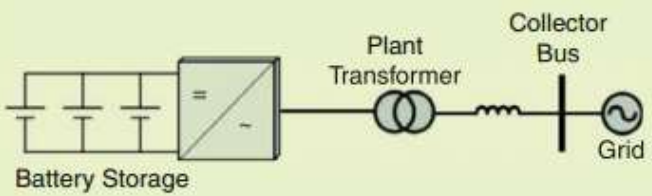
|  | √** | √ | √ | √ |
|  | √* | √ | √ | √ |

*Synthetic rotational inertia-like response possible at any operating conditions.
**Synthetic rotational inertia-like response possible if curtailed with headroom.

IEEE Power and Energy Magazine, March, 2017

# Breaking news

- Ukrajna Csernobilban kívánja megvalósítani a világ „legnagyobb” napelemes erőművét
- (Krím félszigeten maradt jelentős kapacitás)
- 12 $km^2$
- 1000 MW
- Kínai együttműködés

*Köszönöm a figyelmet!*