Samir ROMDHANE
Laboratoire Matériaux Avancée et Phénomènes Quantiques

Faculté des Sciences de Tunis
Tunisie

# Presentation overview

**Tunisia : General Information**

**Tunisia : Challenges**

***Energy***

***Water Scarcity***

***Unemployment***

**Solar Energy in Tunisia**

**Overview on our research activities**

**Conclusion**

# Tunisia : General Information

Area : 165,000 $km^2$ (0.5 % Africa)

Population : 11 M (1% Africa )

Gross Domestic Product of 33.5 B € (2.5% Africa )

Gross Domestic Product of 2 500 B € (Germany)

(2011)

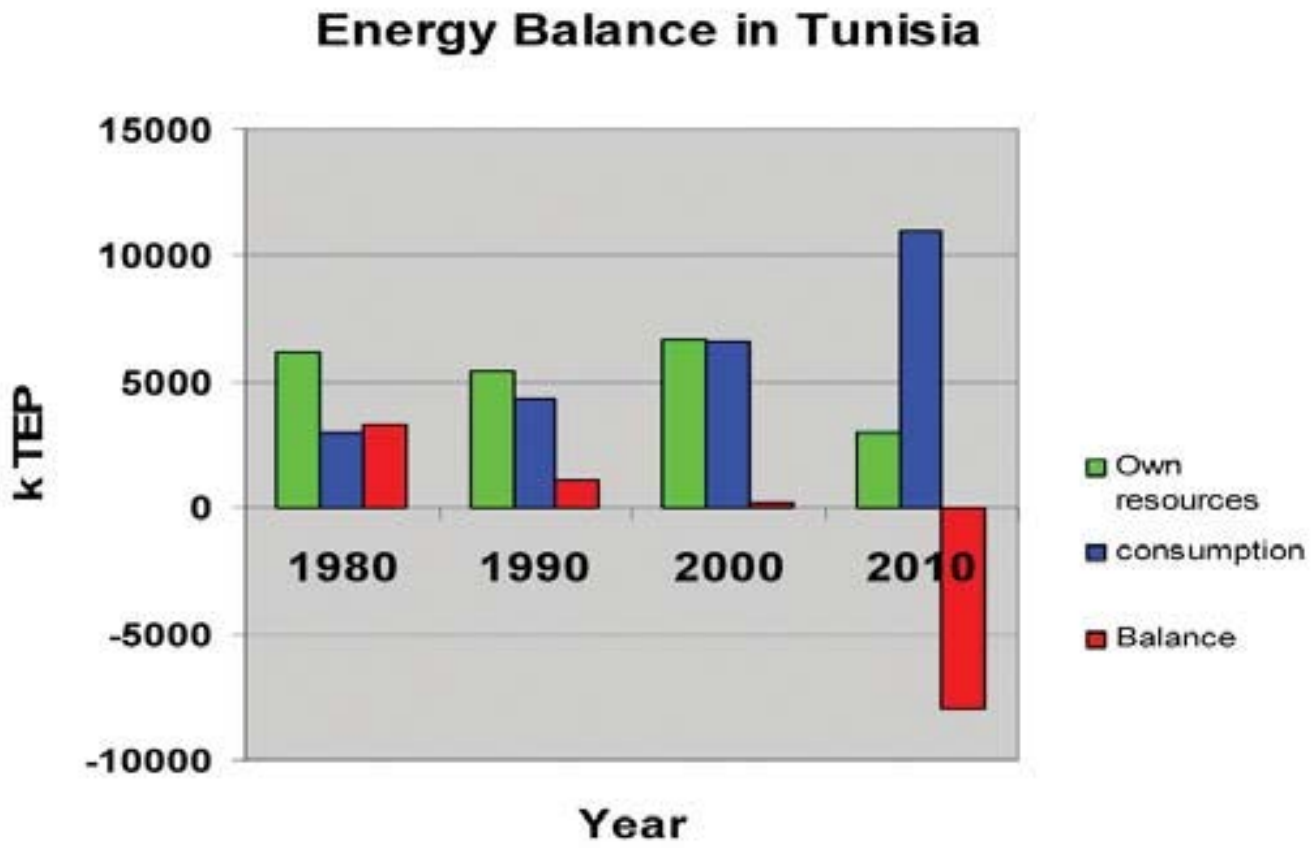
# Challenges of Tunisia

**Energy**

**Water**

**Jobs**

# *Energy in Tunisia Overview and challenges*




**1 kTEP = 1000 tons Oil = 11628 KWh**

# Government Energy subsidies

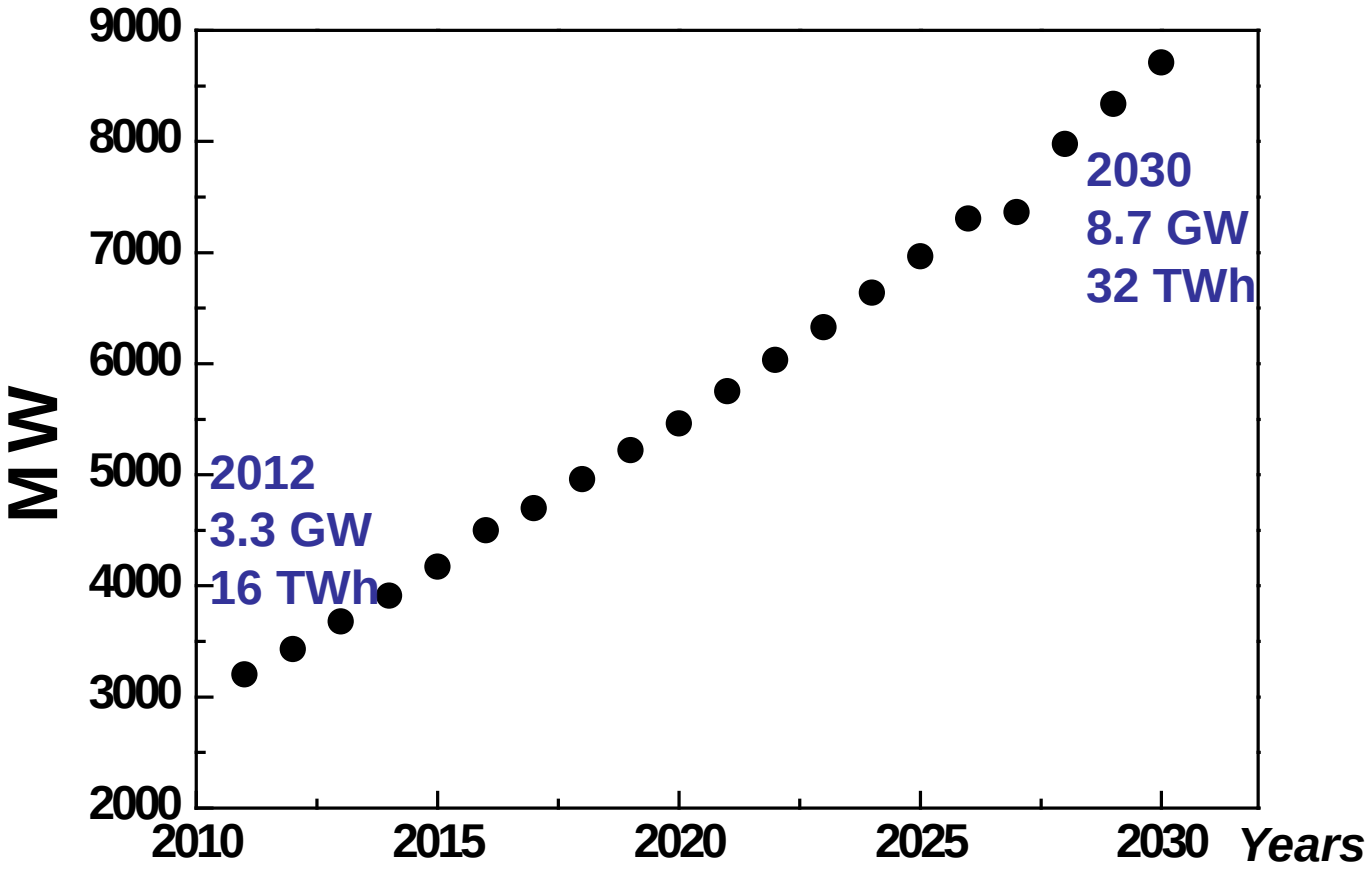
| Fuel prices € per liter | | | Electricity Households € per kWh | Natural Gas Households € per kWh |
|---|---|---|---|---|
| | Unleaded (Euro95) | Diesel (Gazole) | | |
| Tunisia | 0.735 | 0.540 | 0.0810 | 0.0136 |
| Germany | 1.745 | 1.552 | 0.2541 | 0.0574 |

**Total amount of subsidies estimated for 2012**

**1.1 → 1.5 B €**

**8.55 → 11.80 % of the Total budget ( 12.7 B €)**

# Forecasting Electricity Demand until 2030




Evolution of the peak load until 2030 according to the of strong socio-economic scenario by STEG

STEG : The Tunisian Electricity and Gas Company

# *Water Scarcity in Tunisia*

An arid country with limited water resources

Renewable water availability of 424 $m^3$ per capita (2012)

Renewable water availability of 320 $m^3$ per capita (2030)

FAO consider levels of less than 1,000 $m^3$ per person as a severe constraint to socioeconomic development and environmental sustainability

# *Water Scarcity in Tunisia*

Tunisia uses more than 90 % of the available water resources

Irrigation accounts for 83% of the used water resources

The allocated water for irrigation will decrease from 5500 to 4000 $m^3$ per ha at 2030

Decrease of agricultural production

→Increase of wheat and food importation
→Increase of the amount of subsidies (650 M €)

# *Energy-Water-Food subsidies*

Average water costs for households 0.435 € per $m^3$
Desalinated brackish water costs (4% of total production) 0. 83 €

Water prices : 0.085 →0.15 € households & 0.52 € Tourism

Total amounts of subsidies for energy and food (2012)

**1.75 → 2.15 B €**

**13.7 → 16.9 % Total budget 12.7 B €**

**Budget** : **Functioning and investment**

Ministry of Education : **1.85 B €**
Ministry of Higher Education and Scientific Research : **0.75 B €**
Ministry of Public Health : **1.65 B €**

# *Unemployment in Tunisia*

| | Active according to educational level | | Employees by education level | | Unemployed by education level | |
|---|---|---|---|---|---|---|
| | X 1000 | % | X 1000 | % | X 1000 | % |
| N. A | 368.5 | 9.58 | 339.1 | 10.7 | 29.4 (8%) | 4.2 |
| Primary Education | 1271.5 | 33 | 1113.7 | 35.5 | 157.9 (12.4%) | 22.4 |
| Secondary Education | 1457.7 | 37.9 | 1157.9 | 36.9 | 299.8 (20.5%) | 42.5 |
| Tertiary Education | 746.9 | 19.4 | 529.1 | 16.9 | 217.8 (29.2%) | 30.9 |
| Total | 3844.6 | 100 | 3139.8 | 100.0 | 704.9 (18.3) | 100 |

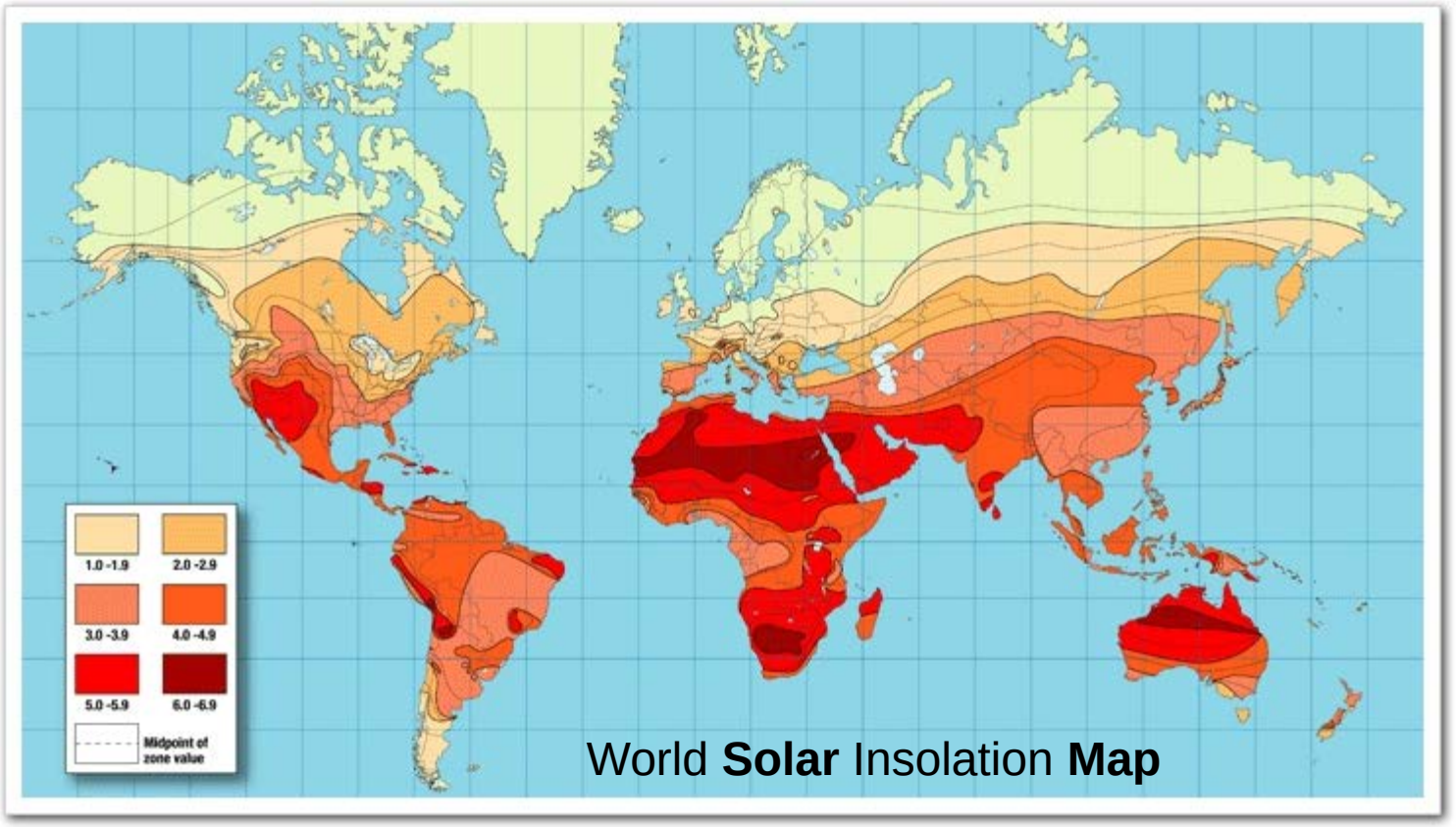
**December 2011**

## *The question*

How we can spur economic growth and sustainable development in Tunisia ?

Tunisia's policymakers must develop a new strategic vision for growth that will enable the economy to absorb the available human capital

# Solar Energy in Tunisia




morgansolar.wordpress.com/.../world_map

# *Energy in Tunisia Overview and challenges*

## Strategic Study of the Energy Mix for Electricity Generation in Tunisia

ANME

الوكالة الوطنية للتحكم في الطاقة
Agence Nationale pour la Maîtrise de l'Energie
National Agency for Energy Conservation

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

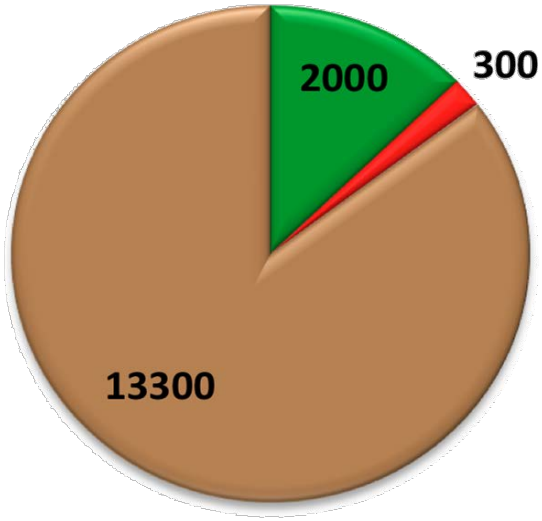
**- Wupperthal Institute for Climate Environment and Energy (Wuppertal, Germany)**
**- Alcor (Tunis, Tunisia)**

# *Energy in Tunisia Overview and challenges*

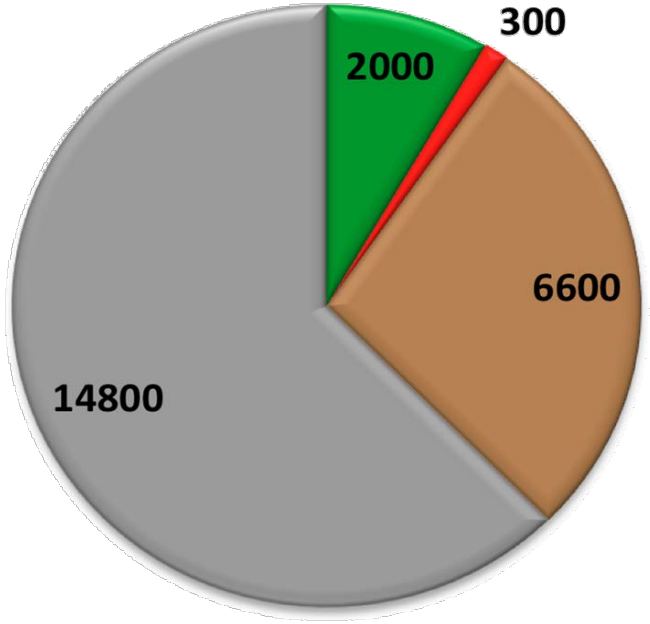
| | Typical cost of generation (€2010/MWh) | | | Local integration rate % |
|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2010-2030 |
| Gas turbines (opened cycle, OC) | 130 | 148 | 155 | 15 |
| Gas turbines (combined cycle, DC) | 61 | 73 | 78 | 20-25 |
| Supercritical coal station pulverized | 63 | 63 | 64 | 20-25 |
| Nuclear plant (Generation III, PWR) | 61 | 62 | 63 | 5 |
| Wind farm, onshore | 60 | 51 | 49 | 43 |
| Photovoltaic power station | 181 | 104 | 78 | 41 → 71 |
| Thermo-solar power station (CSP) cylindro-parabolic 6 H storage | 224 | 182 | 163 | 46 → 57 |

# Challenges of the future energy system

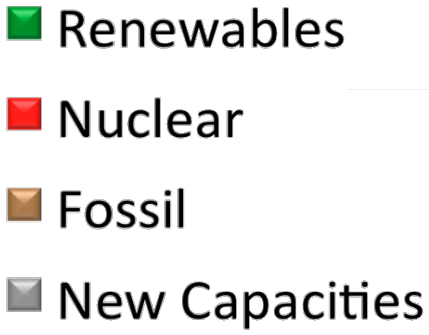
**World Power 2008 (in GW)**




**World Power 2050 (in GW)**

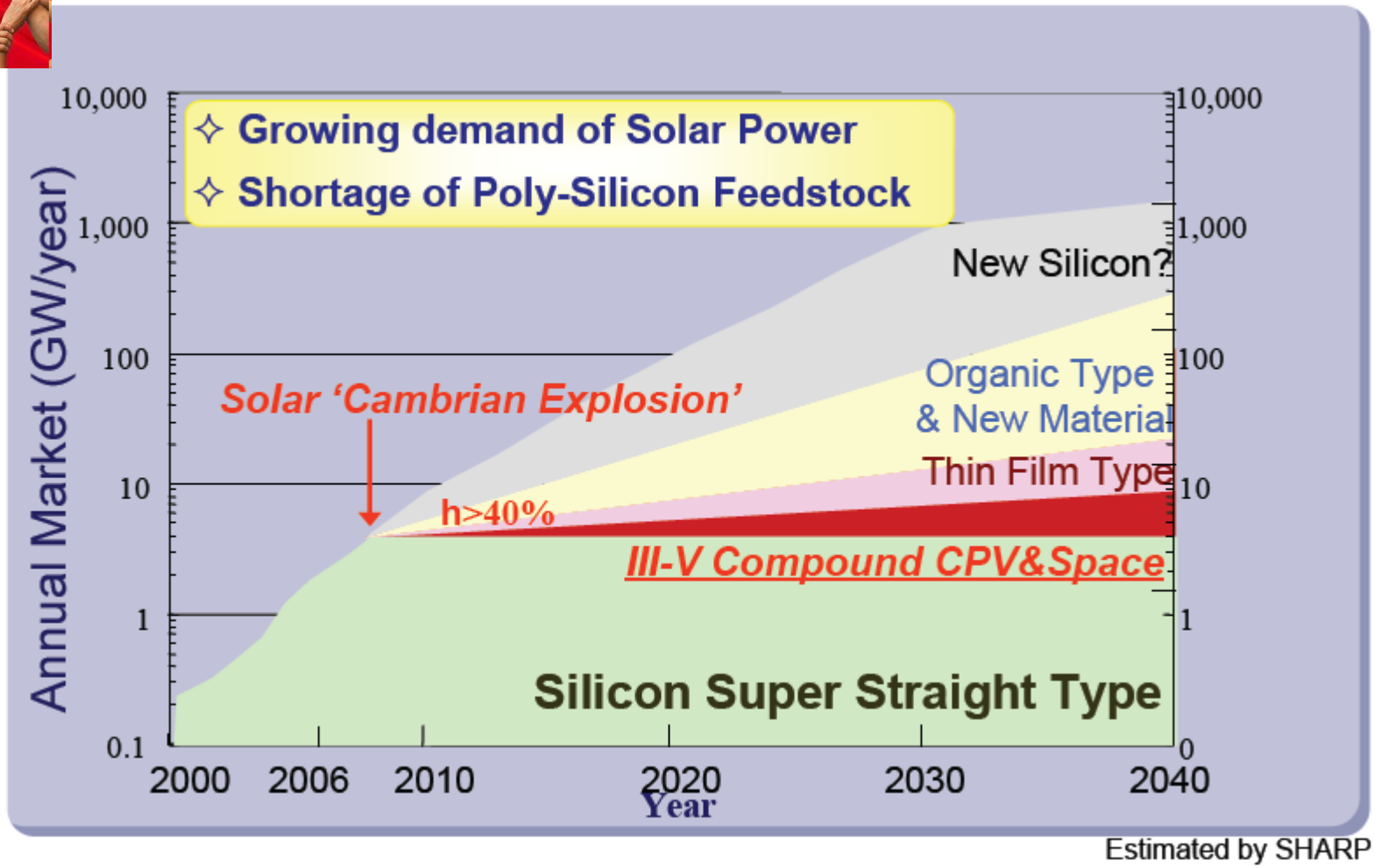



50% reduction of fossil fuels




**What is the material to solve global energy crisis?**

# Materials for PV cell




**Among PV cells, Silicon based cell is popular. The investment in Silicon R&D is essential to bringing down costs, as well as to ensuring our next generations of consumers have technologies ready to meet the mounting demands for energy in this 21st century.**

# Solar Energy in Tunisia

## Advantage of Organic Photovoltaics versus Silicon Solar Cells

| Benefits | Silicon Solar Cells | Organic Photovoltaics |
|---|---|---|
| Environmental | - require huge amount of energy<br>- uses many toxic gases<br>- some contain a cocktail of arsenic, cadmium and titanium | - mass produce using less energy<br>- biodegradable<br>- organic can be recycled |
| Economic | | cheaper to produce |
| Installation | - require direct sunlight<br>- without shadows | generate power from light from any direction and of any intensity |
| Power Output | degrade at the rate of 1% per year | Efficiency is increasing |
| **Development** | | |

**http://www.skyshades.co.uk/opv-vs-silicon-solar-cells.html**



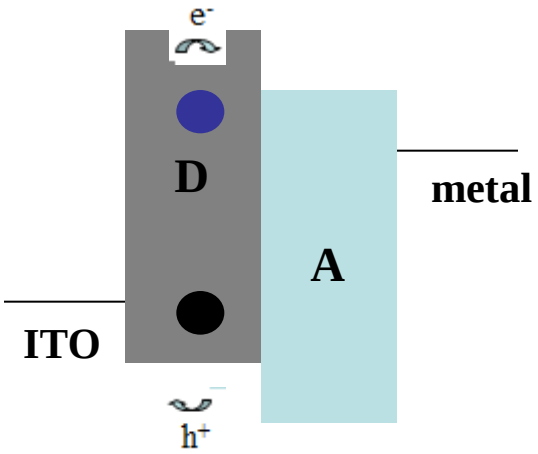
# Disadvantages of Organic Solar Photovoltaic

- Photon absorption does not directly generate free charge carriers.

- Low efficiency,low stability and low mobility.

- Degradation under environmental influences,
  oxidation effects and temperature variations.

# Process of organic photovoltaic cell




$\eta_{IQE} = \eta_{ED}\eta_{CT}\eta_{CC}$

- Light is absorbed in the polymer layer
- Absorption creates a bound electron-hole pair (exciton)
- Exciton is split into separate charges which are collected at contacts

**Exciton diffusion ($\eta_{ED}$)**

Exciton diffusion over ~$L_D$ (~20 nm)

**Charge-transfer reaction ($\eta_{CT}$)**

Exciton dissociation by rapid and efficient charge transfer

**Collection of the carriers ($\eta_{CC}$)**

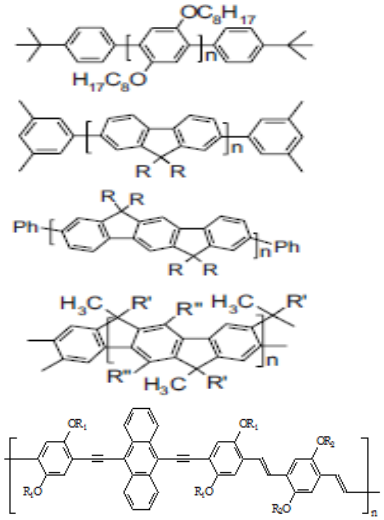
Charge extraction by the internal electric field

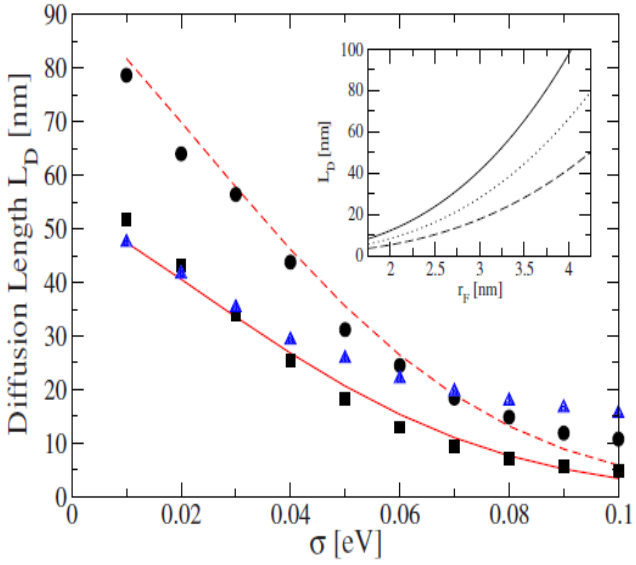


M. A. Saidani, A. Benfredj, S.Romdhane, F.Kouki, H. Bouchriha, **Phys. Rev. B** 86 (2012) 165315.

# *Application of the model*

| Polymer | σ (meV) |
|---|---|
| MeLPPP | 29 |
| PIF | 43 |
| PF2/6 | 39 |
| DOOPPP | 70 |
| AnE-PVstat | 23,45 |






$\eta > 8\%$

According to the works of Athanasopoulos et al., we can estimate the diffusion length of excitations, which measures about 76 nm


Athanasopoulos et al., **Phys. Rev. B** 80 (2009) 195209.

S. T. Hoffmann, E. Scheler, J. Koenen, M. Forster, U. Scherf, P. Strohriegl, H. Bässler, A. Köhler, **Phys. Rev. B** 81 (2010) 165208.

# Conclusion

**Problems of scarcity of water, lack of energy and unemployment are common for MENA countries.**

**No efficient solution was already proposed.**

**We need to think different to successfully helps solving these problems.**

**Need to improve our experience to elaborate new strategies.**

**Use of solar energy is a part of solution. But how?**

**Every scientist has to provide the technical expertise, the resources, the creativity and innovation, and the belief.**

Thanks for your attention

# Operation of Organic Solar Cells