

Bulgarian Academy of Sciences

Opportunity for the Development of Photovoltaic Energy in Bulgaria



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18 April 2018

PV irrigation seminar

*Central Laboratory of Solar Energy
& New Energy Sources*

Opportunity for the Development of Photovoltaic Energy in Bulgaria

MASLOWATEN seminar, Sofia, 18 Apr 2018



- I. Legislation in PV sector
- II. PV systems – current state
- III. Potential in Irrigation sector
- IV. New Developments
- V. Future Outlooks

I. Legislation in PV sector

EU frame: Directive 2012/27/EC (RES targets), Directive 2010/31/EC (Zero Energy Buildings)

National frame: ZEVI law (v.2015),

Energy Stock Exchange “web platform for intraday prices-min100kWh”(March 2018)

No more feed-in-tariffs, free market prices +premium for PV plants above 4MWp (July 2018)

National targets(2020): 16% RES in energy mix(OK-2015), 10% RES in transport sector

National plan –NZEB (new buildings after 2018), National plan- E-mobility(2017)

Main funding: EU funds and grant schemes, small private investments

National programme for EE in multi-family household buildings

Recent activity: PV market recovering after the low activity in 2015-2017

Short procedures only for rooftop PV projects up to 30 kWp in urban areas, 200kWp industrial roofs

Moderate municipality energy projects for EF&RES in buildings

Small isolated PV projects intended for self-consumption

National energy figures:

Total installed PV power - 1 043 MWp,

PV production - 1 325 472 MWh/yr

(DKEVR-2017)

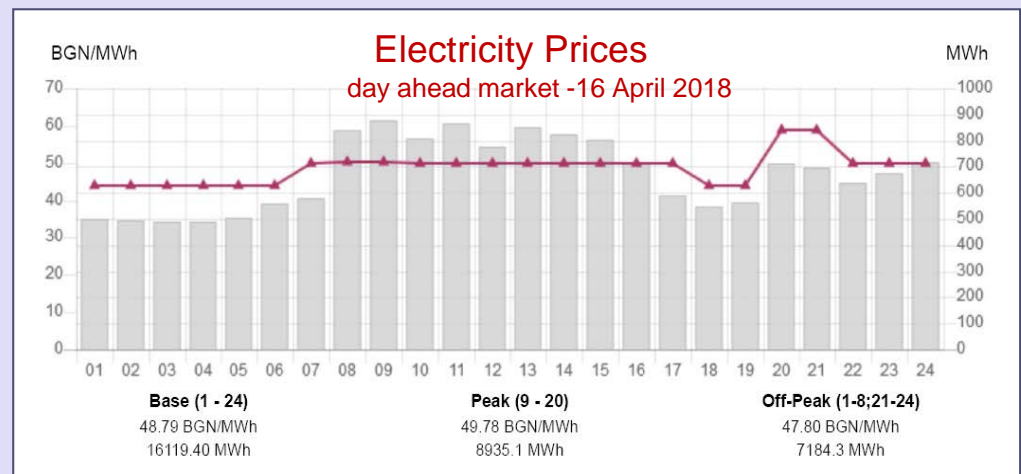
Announced interest for new grid connections

– 495 MWp (2018-2026)

Peak hourly load - 7.69 GW

on Jan. 10 2017 (18:00)

(ESO)





PV installations in BG:



Big PV plants ~70%



Industrial Bi-PV ~25%



Small bi-PV ~5%

II. PV systems -current state

PV sector still in transition:

- Transition of PV plants owners
- Transition in prices of PV electricity
- Transition in business models

Grid Operators in BG

| In MW | ESO | EVN | CEZ | Energo-Pro |
|--------------------------|------------------|-----------------|-----------------|----------------|
| Hydro PP, Micro Hydro PP | 1470.8300 | 81.8674 | 185.0490 | 13.203 |
| Wind PP | 435.5 | 37.75 | 18.12 | 265.04 |
| PV PP | 275.781 | 494.866 | 140.475 | 100.854 |
| Biomass and Biogas PP | 13.189 | 1.83 | 6.334 | 0.285 |
| Total: | 2195.3000 | 616.3134 | 349.9780 | 379.382 |



II. PV systems -current state

Varna Airport

Reduction of Airport Carbon footprint

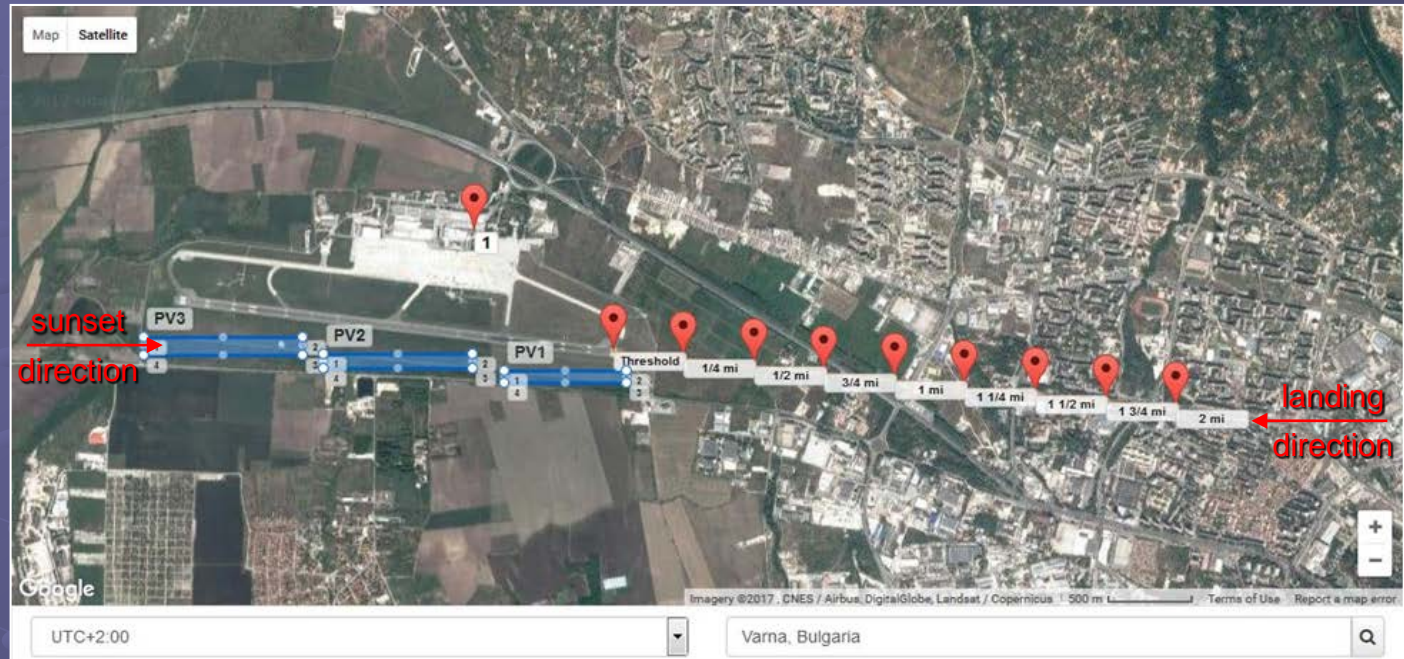
CO₂ Offsetting

PV system design:

PV plant power:
1.2 MWp
PV yield prediction:
1 385 MWh/yr
BMS system

Consumers:

- Airfield lighting
- AirControl tower
- Navigation systems
- HVAC in terminal



Shade and Glare Analysis & Simulations: seasonal and hourly effects

Dangerous zone:

- East part of runway

Recommendations:

- texturized PV modules
- re-orientation -5° East

Solar glare with low to middle intensity

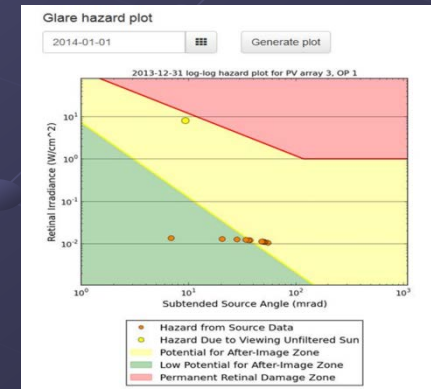
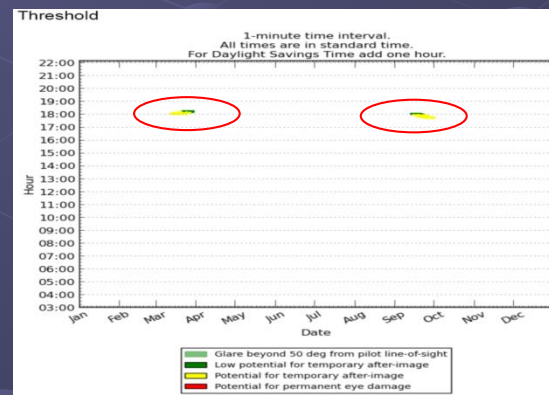
max Irr: 10 mW/cm²

Temporary lost of visual sensitivity

Risk intervals:

20-25 March, 17:30- 18:30

20-25 Sept., 17:30- 18:30

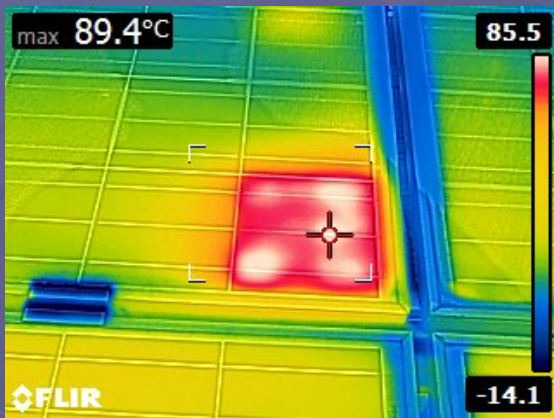


II. PV systems -current state

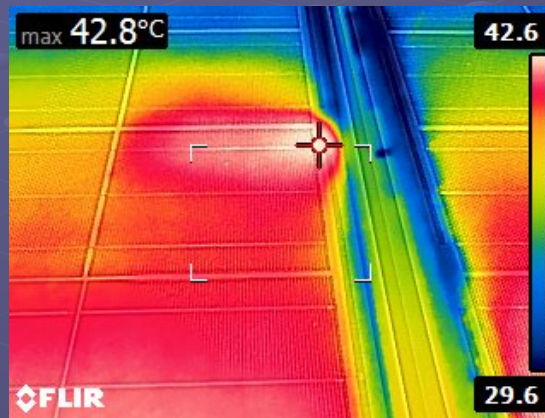
PV plants Monitoring and Performance optimization

Defects in PV modules after 4 years of operation

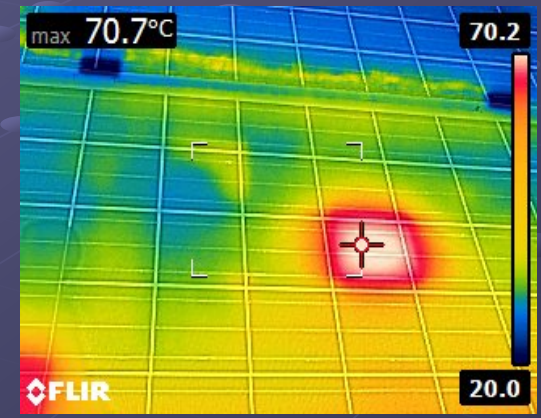
Irreversible defects
in p-n junction of Si solar cell



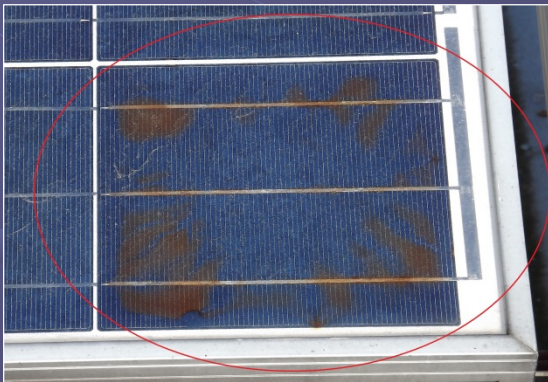
Compromized isolation
between Al frame and PV sting



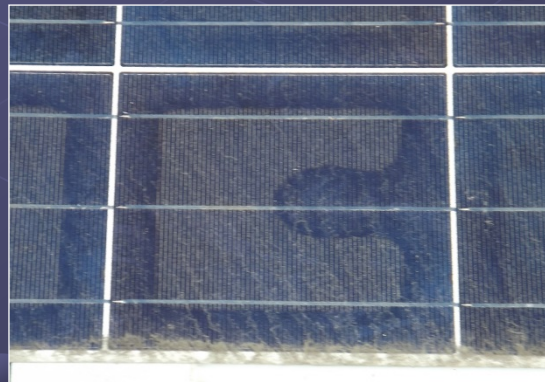
“Hot-spot” defect
in single solar cell



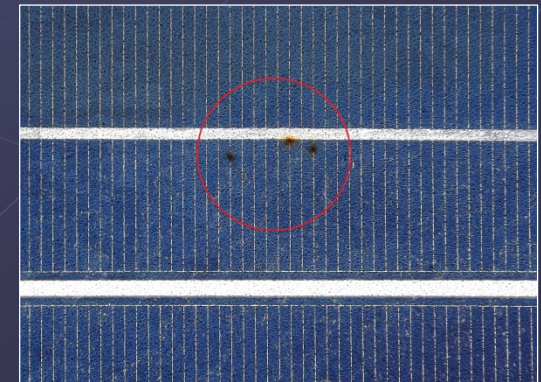
Wide-area resistive load

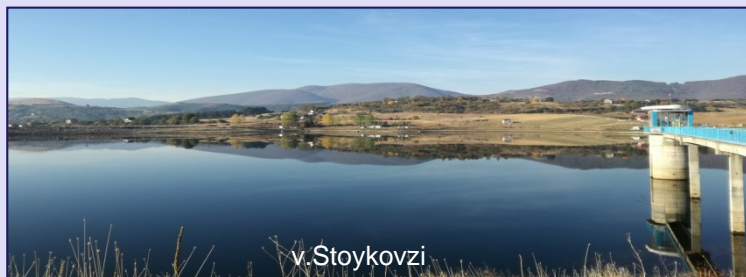


Aging effect of EVA polymer



Pinhole breakthrough in solar cell





III. Potential in Irrigation sector

14 regional irrigation offices

Current state:

Only 2% of BG agricultural area is irrigated mainly from artificial lakes and dams (~6000)
 300 Mln. m³ water for irrigation per year, typical source: micro-dams using open channels
 Limited human potential and financial resources
 Big amount of small fragmented farms, problems with floods control
 Lack of feedback contacts and information grids (SWOT analysis)

National targets:

- enhanced transfer of innovation practices
- new information channels based on IT
- enhanced municipality activity

Most popular agricultural plants:

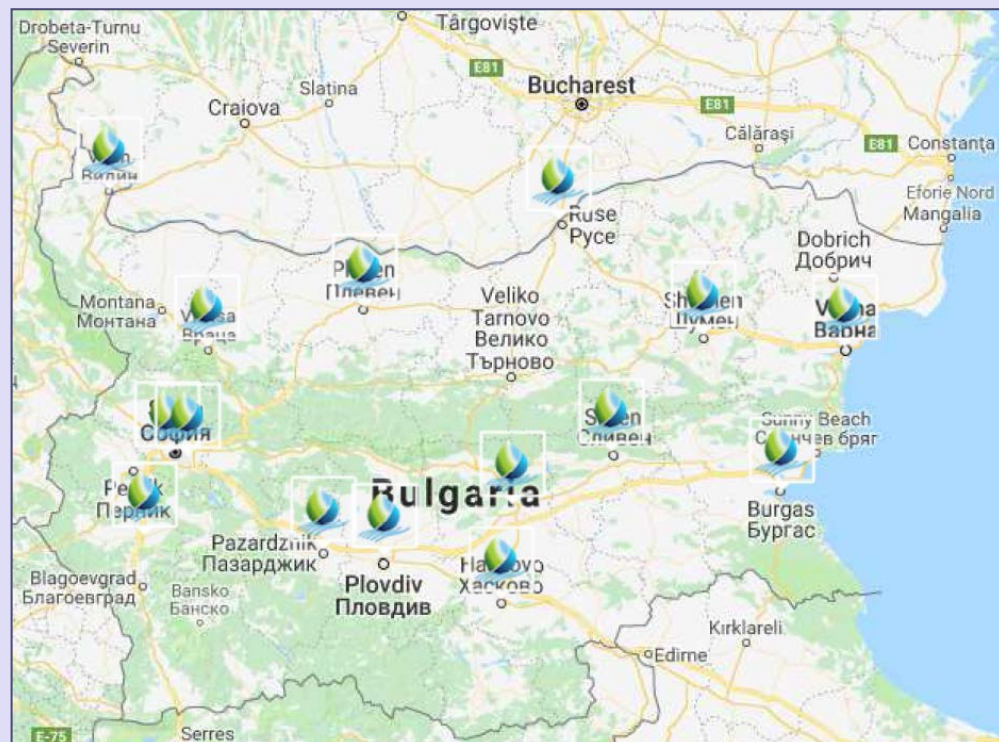
Corn, wheat, rice, barley, vegetables
 potatoes

Shallow irrigation:

- | | |
|---------------|--------------------------|
| SW region | - vegetables |
| Trakia region | - vegetables, corn, rice |
| SE region | - water-melon, tomato |
| NW region | - corn, fruits |

Deep water pumping:

- | | |
|-----------|----------------------|
| NE region | - wheat, water-melon |
|-----------|----------------------|



III. Potential in Irrigation sector



Wide-area seasonal irrigation in NW region - Rotational system

National strategy:

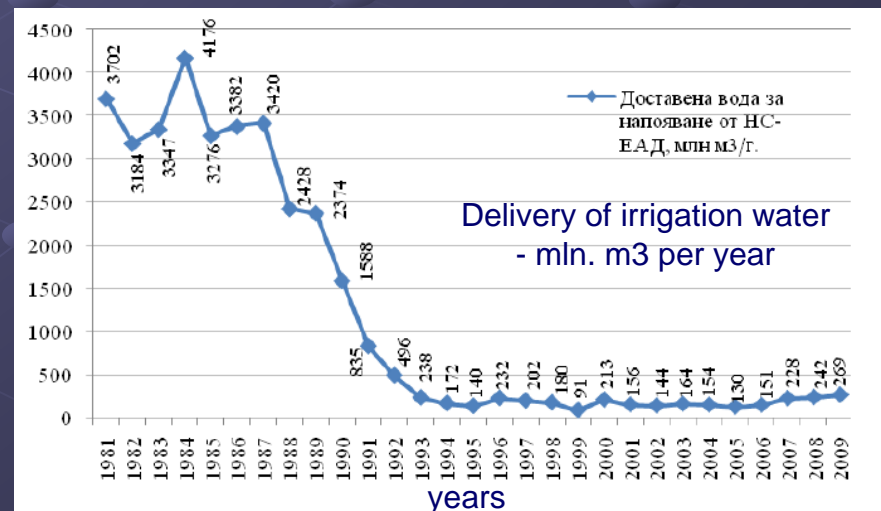
Problems:

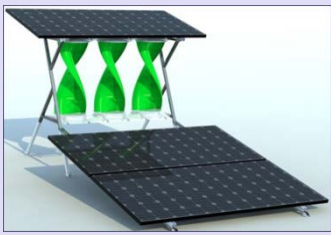
- 40 yrs old infrastructure with high water losses due to leaks
- unsettled ownership and responsibility
- lack of professionals,
- 7 ministries involved in water management

Proposals:

- usage of EU co-funding
- education of new specialists
- tendency for water savings
- enhanced resource monitoring

Total water volume collected in dams - **2 753 mln. m3** (2007)





IV. New Developments

Hybrid Energy Systems

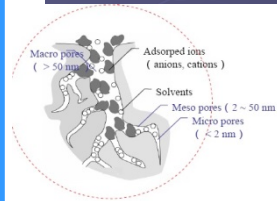
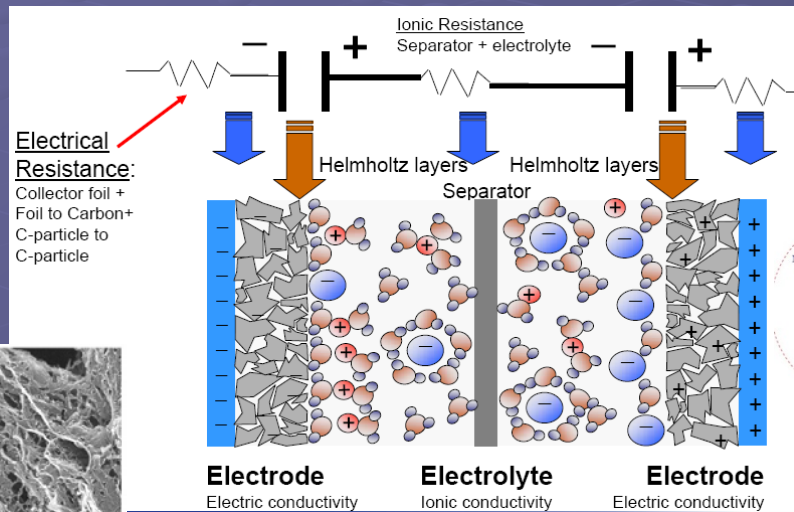
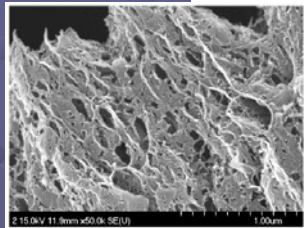
Solar /Wind + Battery storage system connected to LV grid



IV. New Developments

Energy storage using superCAPs

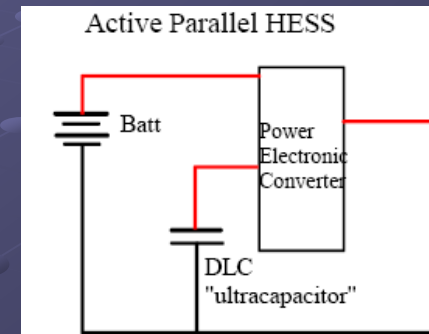
EDLC supercapacitors - Graphene/Active Carbon + Polyaniline



Low-cost Technology: screen-printing, ink-jet printing

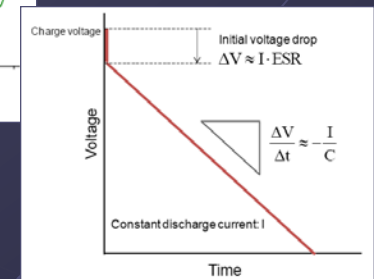
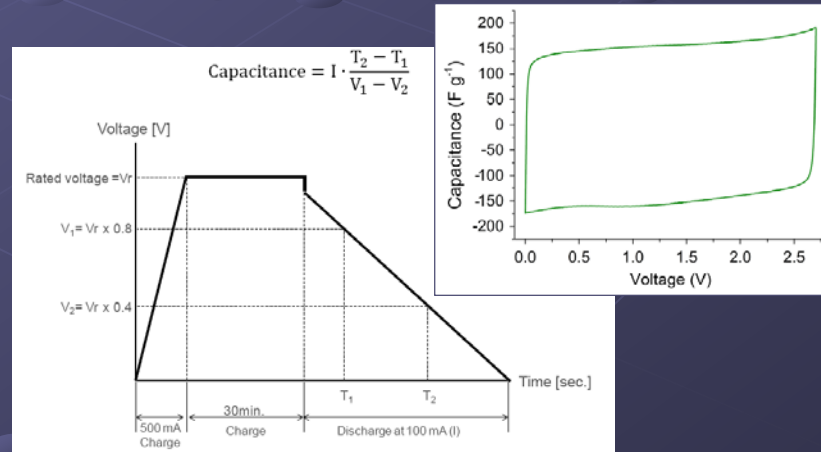
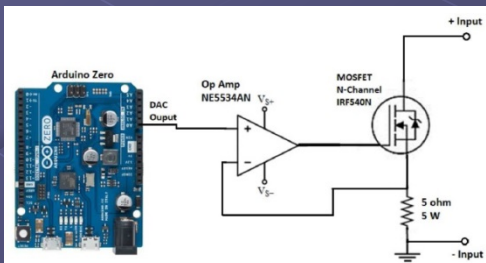


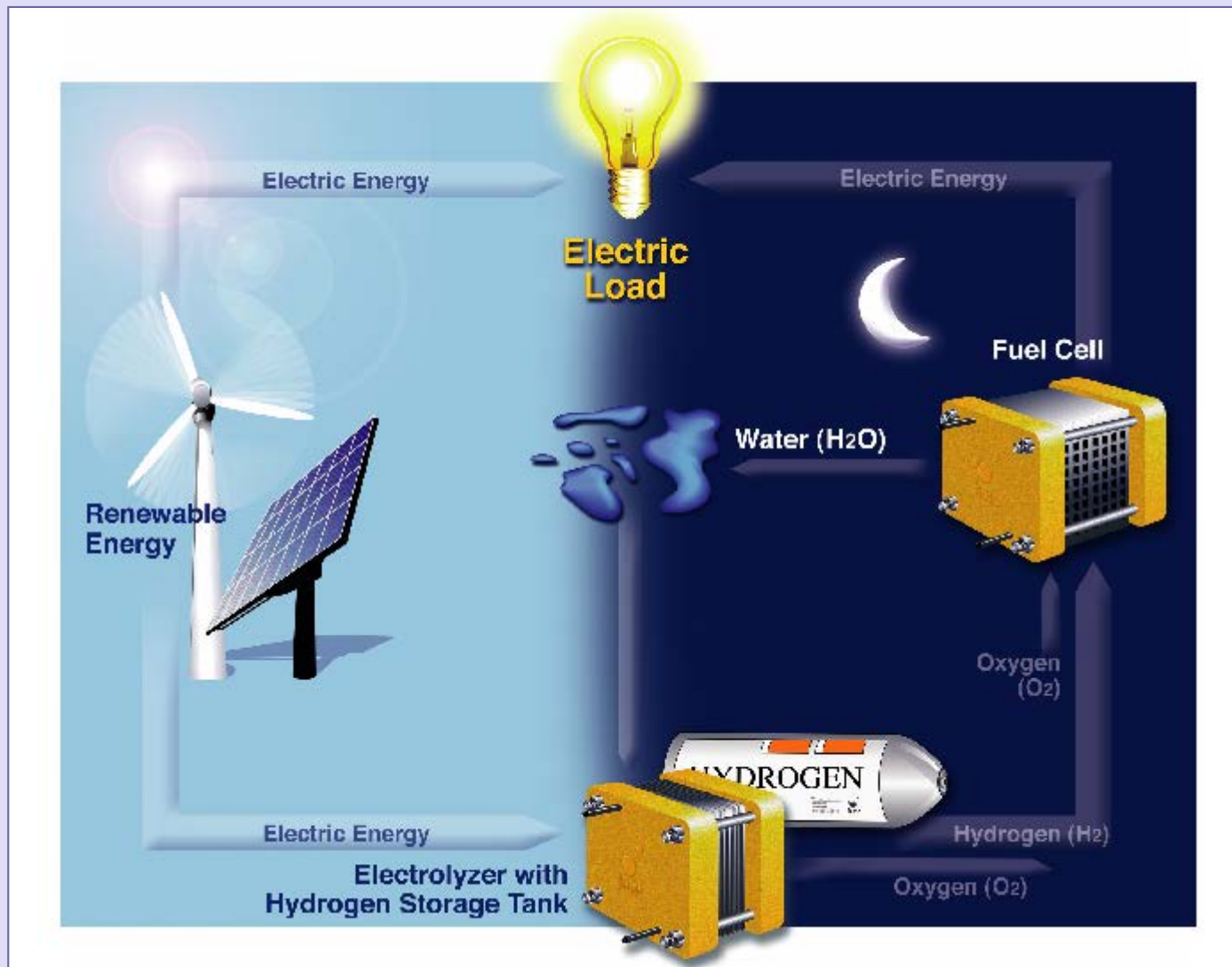
($R \sim 1.5 \times 10^{-6} \text{ ohm-cm}$)
(about $2630 \text{ m}^2/\text{g}$)



Applications: Hybrid batteries
PV module + flat supercaps

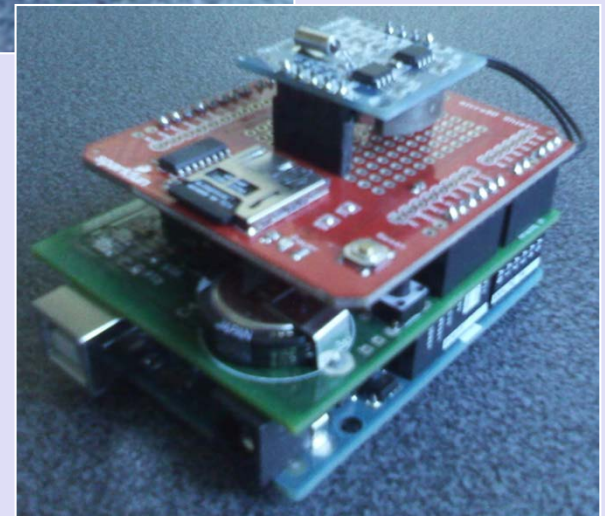
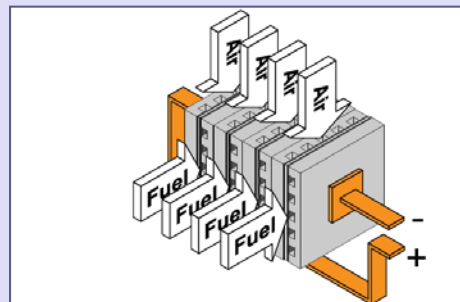
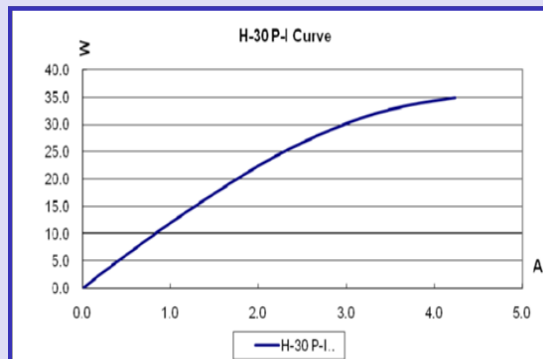
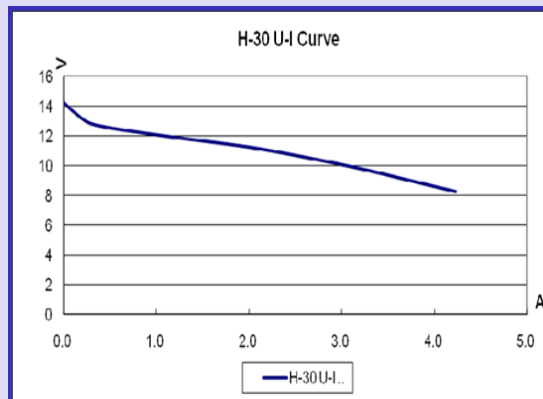
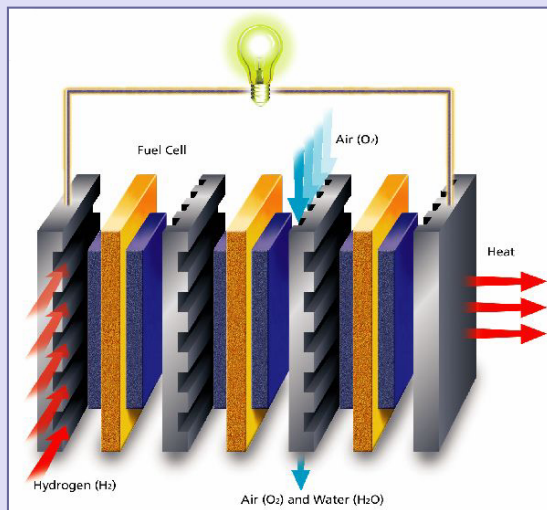
Flexible Electrical Measurements
based on open source (Arduino)





IV. New Developments

PEM Fuel Cells



V. Future Outlooks



PV systems design

- High-land PV pumping systems for drinkable water
- Land irrigation using centrifugal pumps
- Solar heating and cooling using thermo-pumps

Hybrid Storage Systems technology

- PV module/carbon-based superCAPs systems
- Small solar electrolyzers/PEM fuel cell systems



Thank you for your attention !

