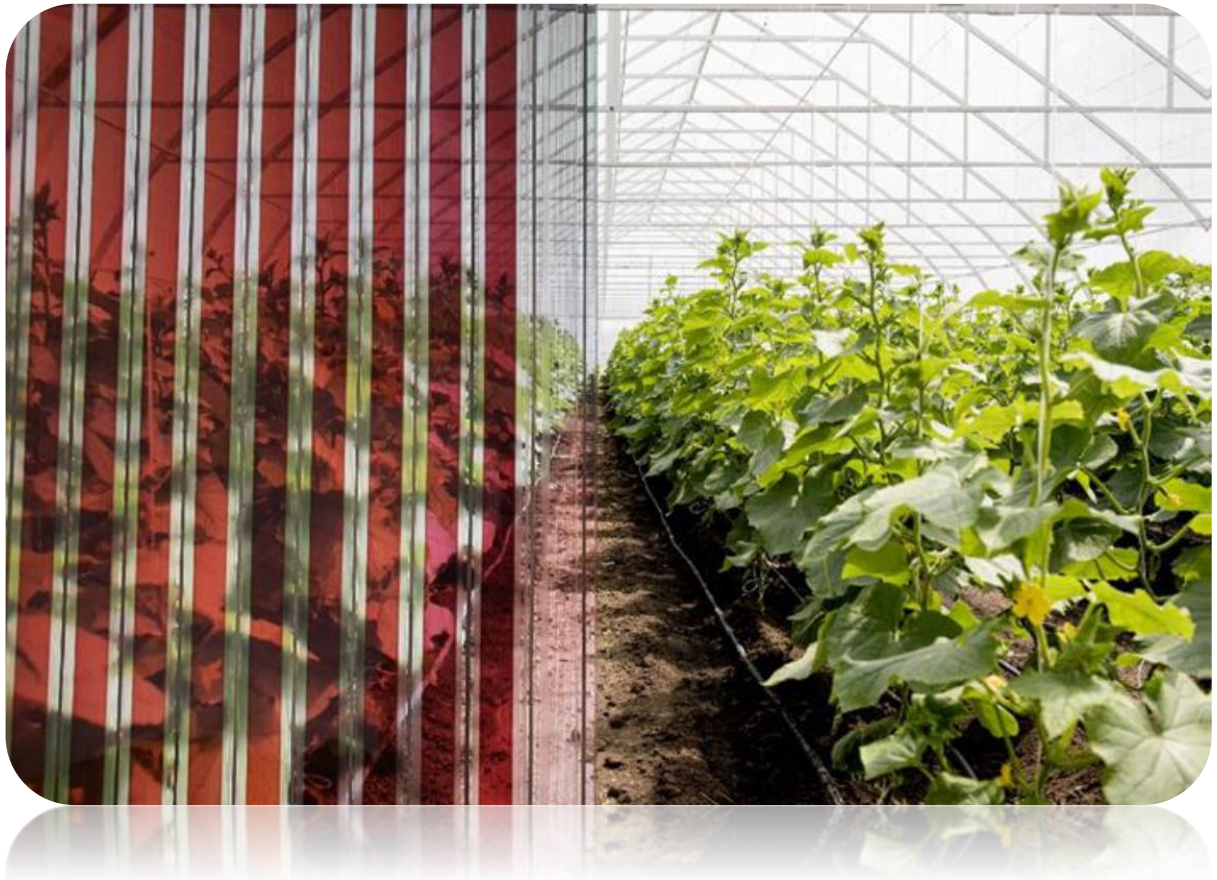
Spectral engineering of translucent solar cells toward the development of next-generation agrivoltaic energy systems

Acronym: AgriTPVEng



Dr. Dimitris A. Chalkias

Dipl.-ing, Ph.D.-ing

Mechanical & Aeronautical Engineer

OMC MED ENERGY CONFERENCE & EXHIBITION

24TH –26TH OCTOBER 2023 - Ravenna, Italy

www.omc.it

Reshaping the Energy Industry: Action for Transition

Dr. D.A. Chalkias is a Research Associate at the N&AML in the Dept. of Electrical & Computer Engineering at the University of the Peloponnese and a Process Engineer at Brite Solar Technologies company, in Greece. He completed his undergraduate studies and postgraduate research at the University of Patras in the Dept. of Mechanical Engineering & Aeronautics, where he was awarded a Ph.D. in 2019.

emails:
chalkias@mech.upatras.gr
chalkias@uop.gr
dchalkias@britesolar.com

Ph.D. dissertation: "Fabrication and characterization of novel hybrid nanocomposites with application in solar cells"

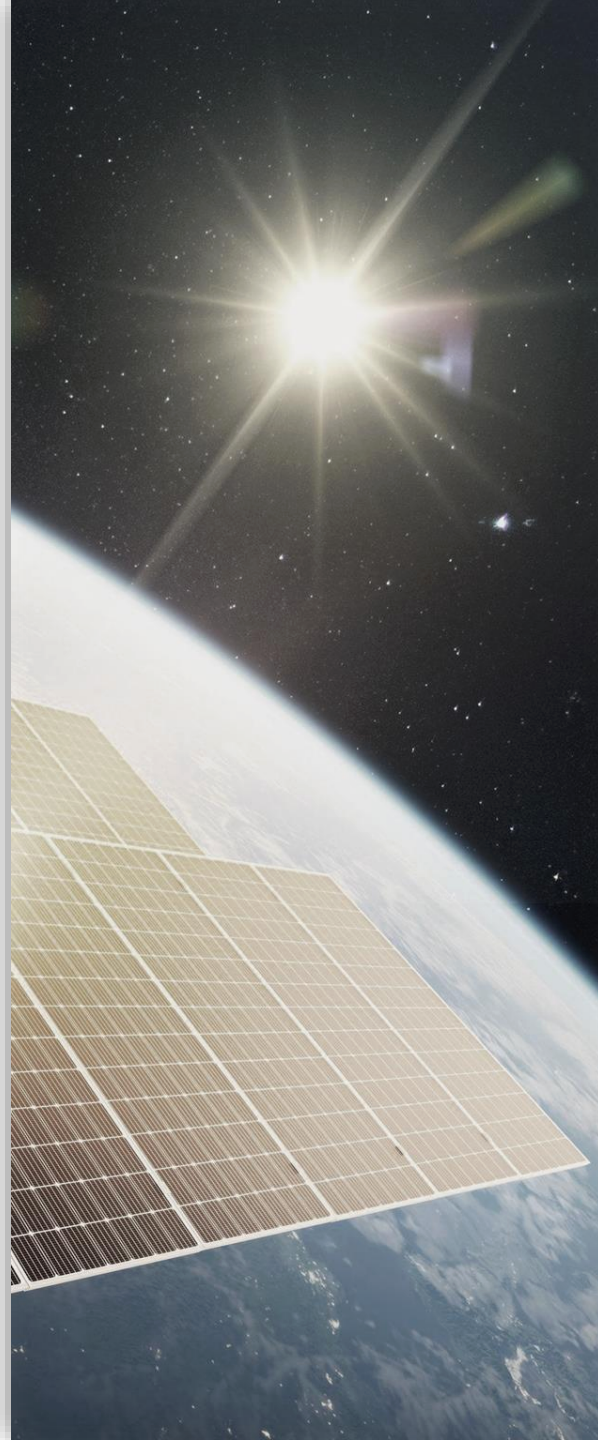
N&AML

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΛΟΠΟΝΝΗΣΟΥ
UNIVERSITY of the PELOPONNESE

Brite SOLAR TECHNOLOGIES

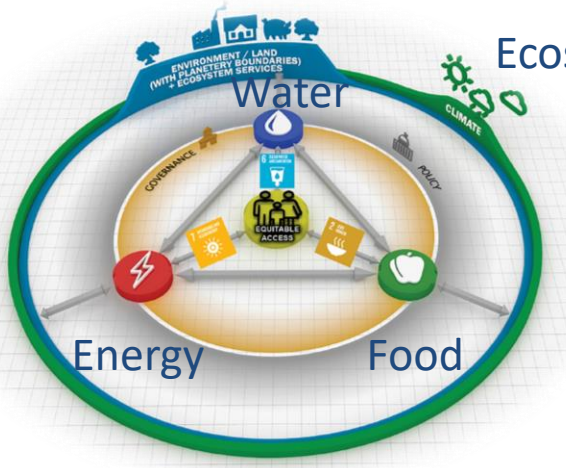
Interests:
- ❑ emerging photovoltaics (PVs) and their upscaling
- ❑ novel agrivoltaic technologies

His research is now focused on perovskite solar cells (PSCs) and dye-sensitized solar cells (DSSCs)
Main upscaling technique under investigation: *piezoelectric drop-on-demand inkjet-printing*

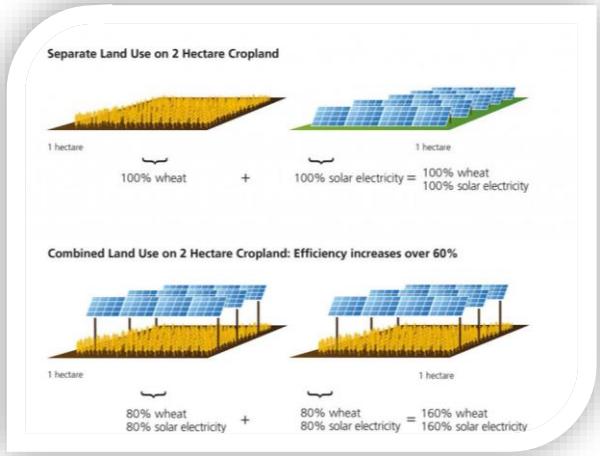


The challenge

Achieve a sustainable management of Water-Energy-Food-Ecosystem (WEFE) nexus



Agrivoltaic energy systems



Country/Region of Application

Patras, Achaia, Greece

Patras is the largest economic, commercial center of the Peloponnese and Western Greece. Patras has one of the largest ports in Greece and is considered the gateway of Greece to the West, both in terms of transport and trade, as well as culture.

Achaia is considered a rich place and its inhabitants are engaged in agriculture, animal husbandry and fishing. A large part of the agricultural production is occupied by cultivation of vineyards with grape crops for the production of mainly wine, table grapes and Corinthian raisins.

The cultivation of vineyards in greenhouses can lead to a significant increase of their development rate (up to 100%, two crops per year).

The usage of renewable energy sources to meet the energy demands of greenhouses (>25% of the total greenhouse costs are related to the energy needs) is considered an emerging and very promising approach.

Objectives of the Project

Toward next-generation agrivoltaic energy systems
(approach: *shared structure and sunlight*)

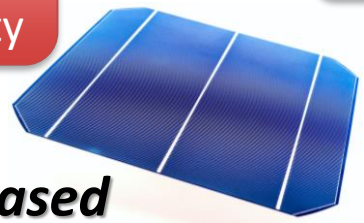
Sustainable management of the WEFE nexus

Development of an innovative low-cost photovoltaic (PV) technology for agriculture-oriented applications

State of the art

Opaque
↓
land scarcity

low development rate of cultivations under them



low performance in diffuse light conditions

Silicon-based solar cells

Emerging translucent PV technologies

inappropriate optical characteristics

low technological maturity

uncompetitive cost

AgriTPVEng

tailored optical characteristics for greenhouses integration
↓
low effect on the photosynthetic action of plants

power production by non-critical spectrum of sunlight for the process of photosynthesis

high performance in diffuse light conditions
↓
no limitations in the orientation

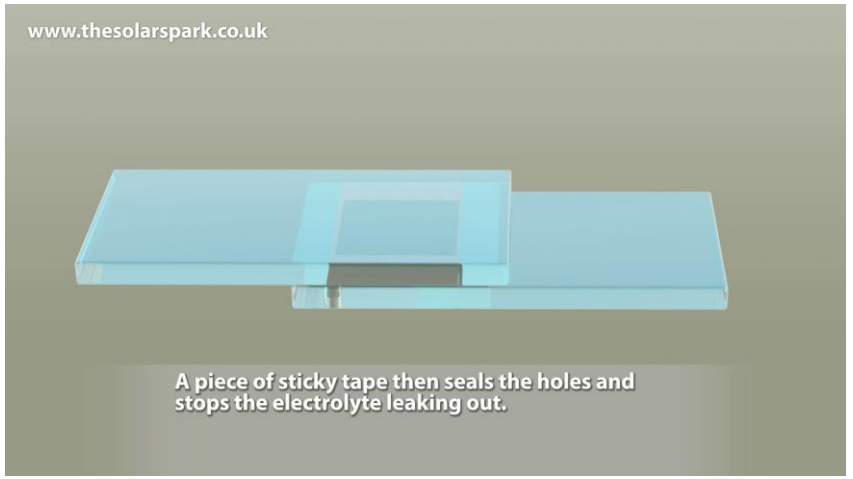
no liquid state solar cell materials (without performance limitations)
↓
improved reliability

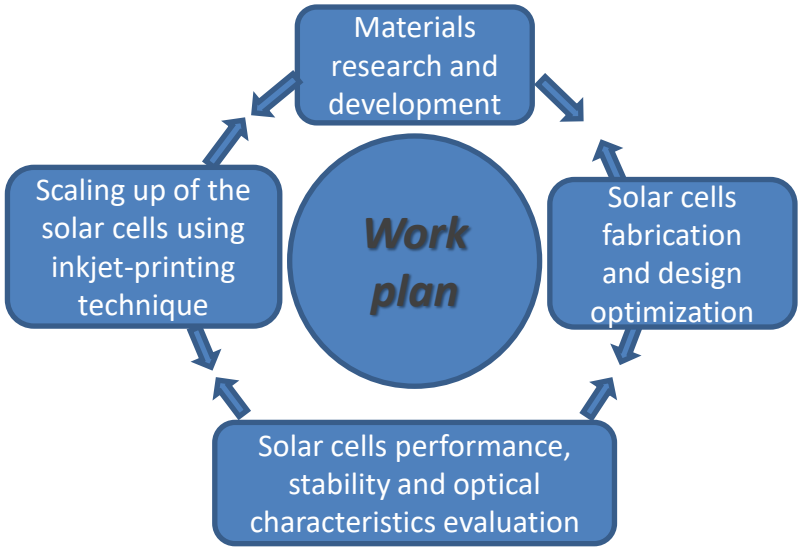
reduction of manufacturing costs with inkjet-printing upscaling

Work Plan and Technical Novelty

*Semi-transparent dye-sensitized solar module fabricated for various applications

Dye-sensitized solar cells (DSSCs)



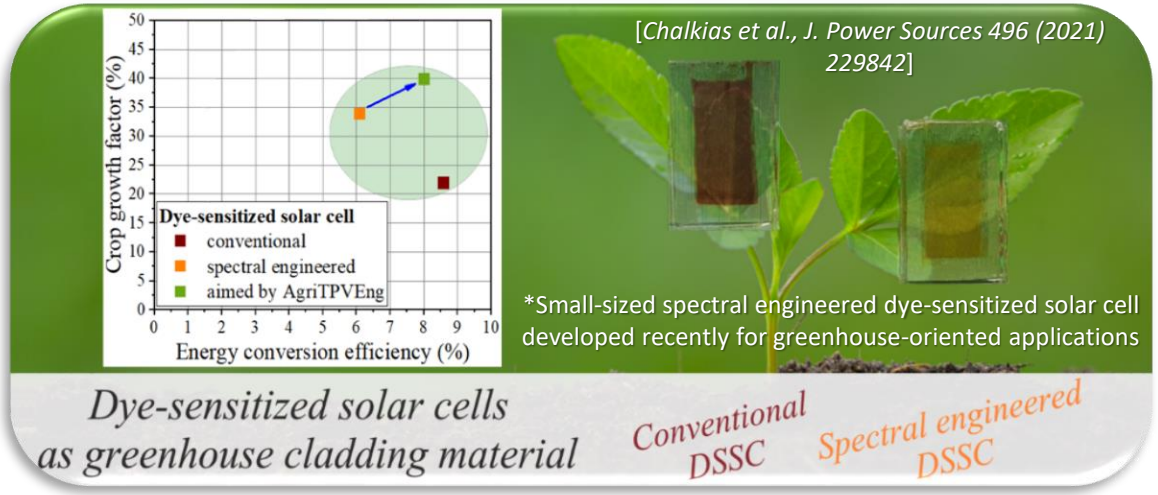


Technical novelty of the project

Systematic spectral engineering of semi-transparent DSSCs for agriculture-oriented applications

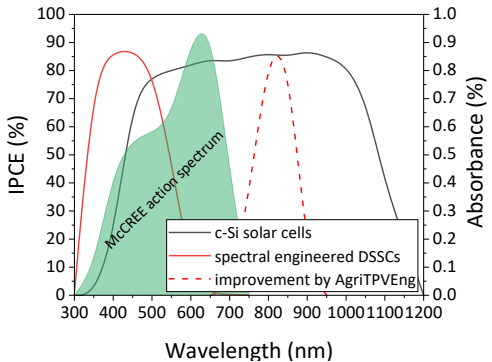
- ✓ Novel dye-sensitizers that will absorb at non-critical wavelengths of light for the process of photosynthesis.
- ✓ Advanced quasi-solid state electrolytes that will demonstrate high transparency in the whole visible spectrum of light, without performance limitations.
- ✓ Novel electrode materials and nanostructures that will demonstrate a low overlap of their absorption spectrum with the corresponding one of chlorophyll.
- ✓ Application of advanced and scalable inkjet-printing technique that will lead to the fabrication of large-sized high transparency solar cells with low manufacturing costs.

Current Stage of Development, Networks and Scalability



Before AgriTPVEng (TRL 4)	Aim of AgriTPVEng (TRL 7)
6% efficiency with 35% crop growth factor	8% efficiency with 40% crop growth factor
employment of conventional liquid state electrolytes and electrode materials	employment of advanced quasi-solid state electrolytes and novel electrode materials and nanostructures
no systematic stability studies	accelerated ageing tests on solar cells according to the ISOS standards
use of conventional laboratory fabrication techniques	use of the advanced and scalable inkjet-printing technique

Possible collaboration with well-experienced laboratories in designing novel dye-sensitizers (Dept. of Chemistry University of Patras Greece, Institute of Chemistry Florence Italy, Dept. of Chemistry University of Cyprus Cyprus, Institute of Technology Izmir Turkey) and startups for upscaling 3rd generation photovoltaic technologies (Patras, Greece), as well as farmers to demonstrate prototypes in operational environment (Greece, Egypt, Tunisia).



Prospects for the development of c-Si / DSSC tandems

The developed PV technology can be evaluated additionally for a variety of cultivations, in different Mediterranean countries, even for them who are characterized by a low average solar potential (high performance of solar cells in diffuse light conditions).

The successful spectral engineering of the solar cells will also open the way for a variety of novel and niche applications.