

Integration of Solar Panels and Microalgae Photobioreactors for Energy Self-Sufficiency and Efficient Carbon Capture

Ciao-Wun Liu, I-Son Ng*

Department of Chemical Engineering, National Cheng Kung University, Tainan, Taiwan

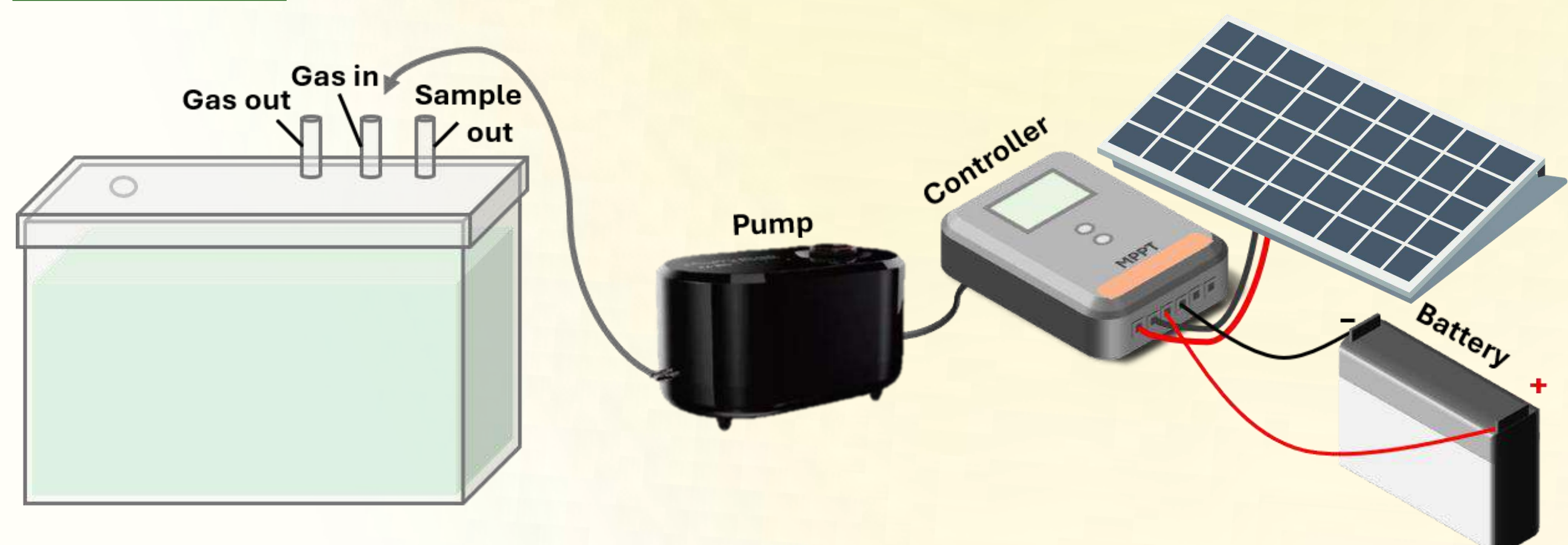
*Corresponding author: yswu@mail.ncku.edu.tw

Background

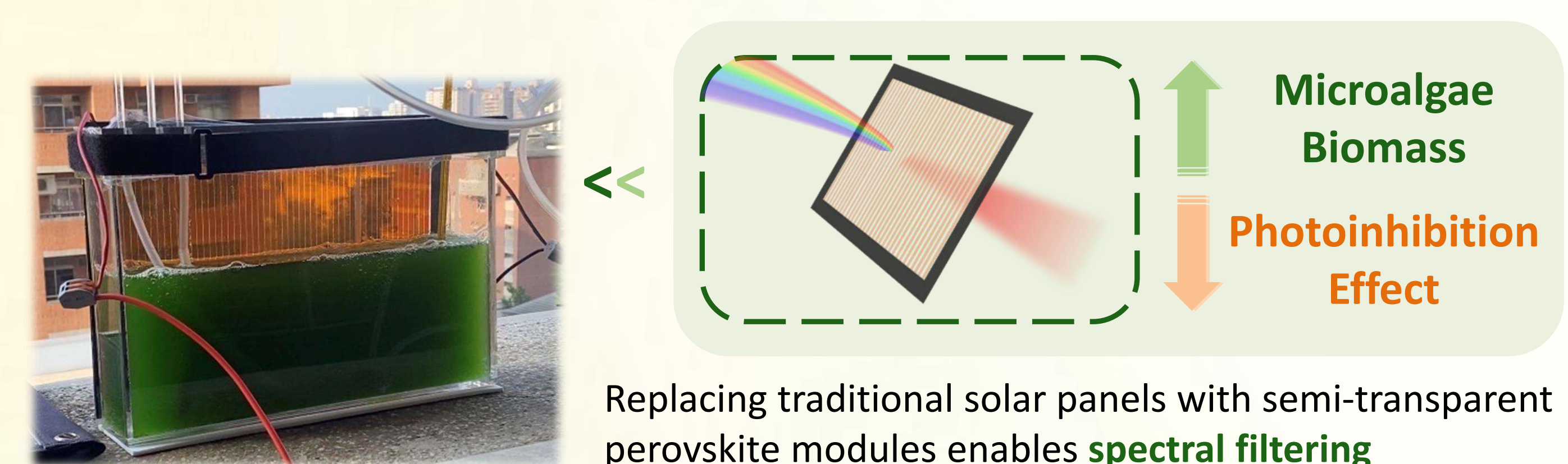
Traditional microalgae cultivation is energy-intensive, hindering the realization of **net-negative carbon emissions**. This study proposes a **self-sustaining outdoor module integrating photovoltaic (PV) panels with flat panel reactors (FPR)** for direct air capture (DAC). Using *Synechococcus* sp. PCC 11901, we evaluated monocrystalline silicon (SSC) and semi-transparent perovskite solar cells (PSC).

Architecture of Photovoltaic-Photobioreactor System

SSC-FPR (Monocrystalline Silicon Solar Panel with Flat Panel Reactor)

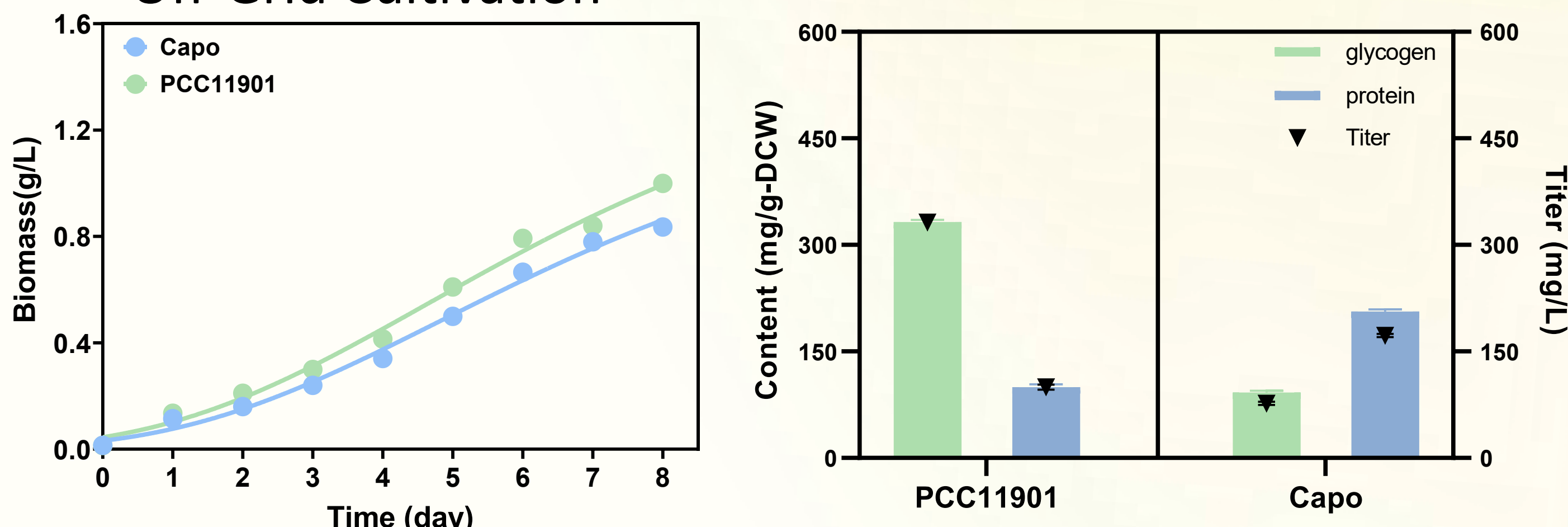


PSC-FPR (Semi-transparent Perovskite Solar Panel with Flat Panel Reactor)

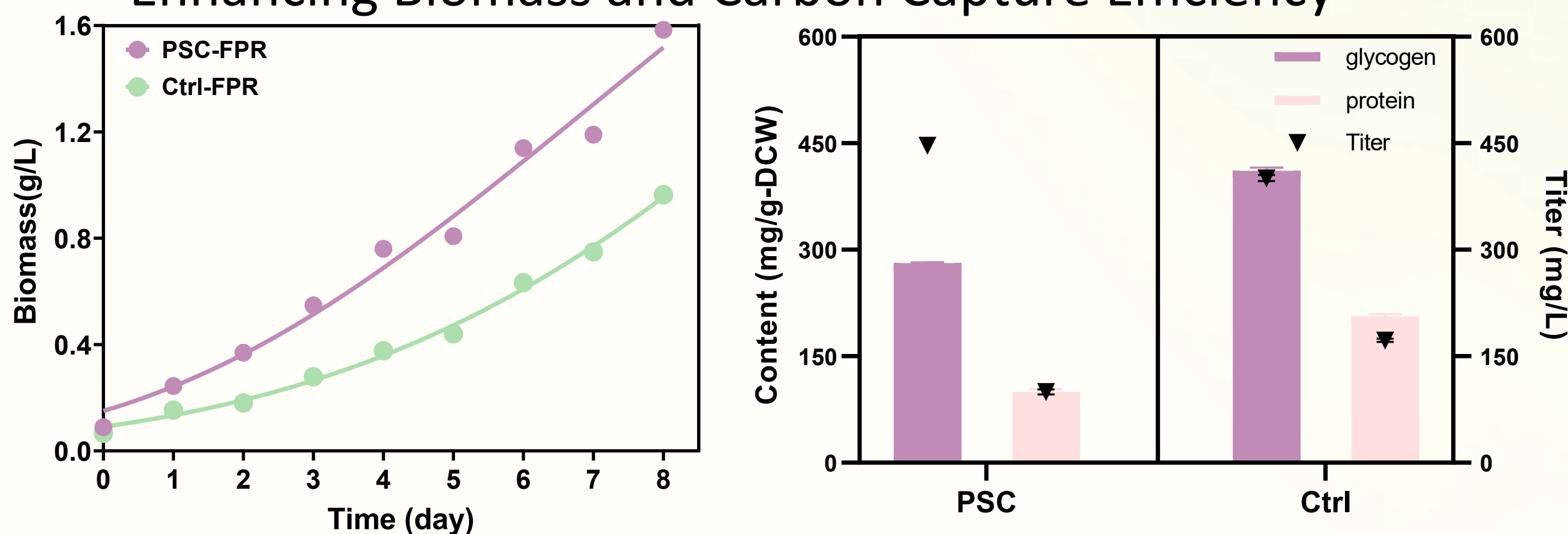


Carbon Capture & Biomass Production

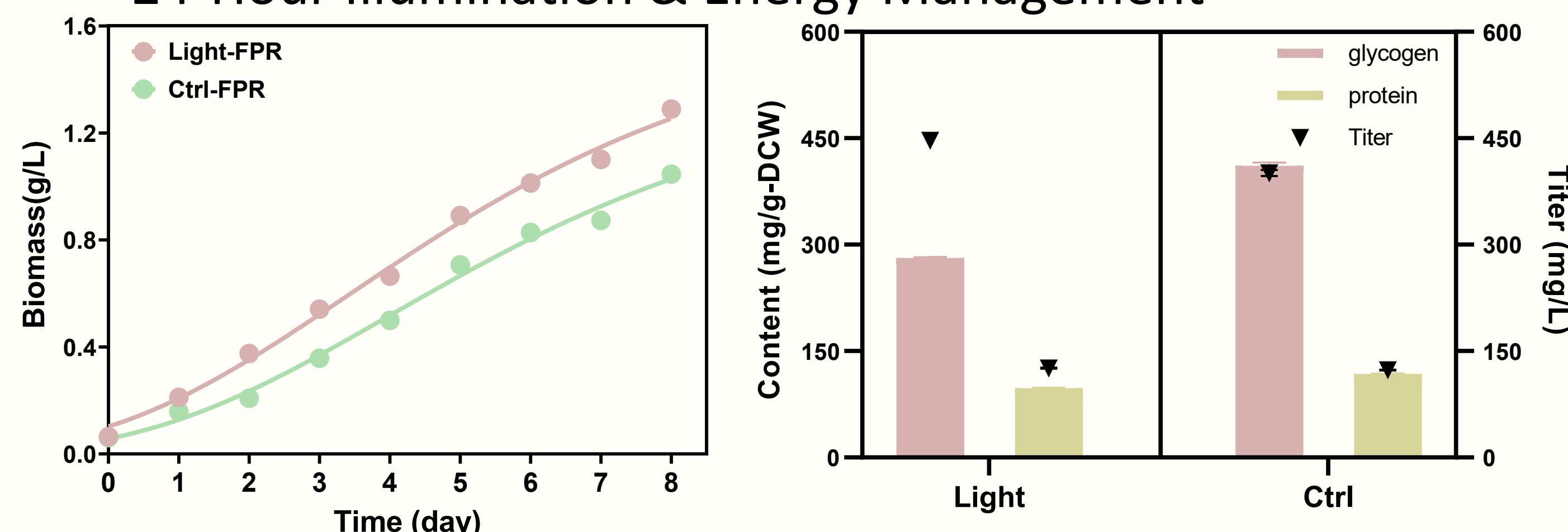
01 Proof of Concept: Off-Grid Cultivation



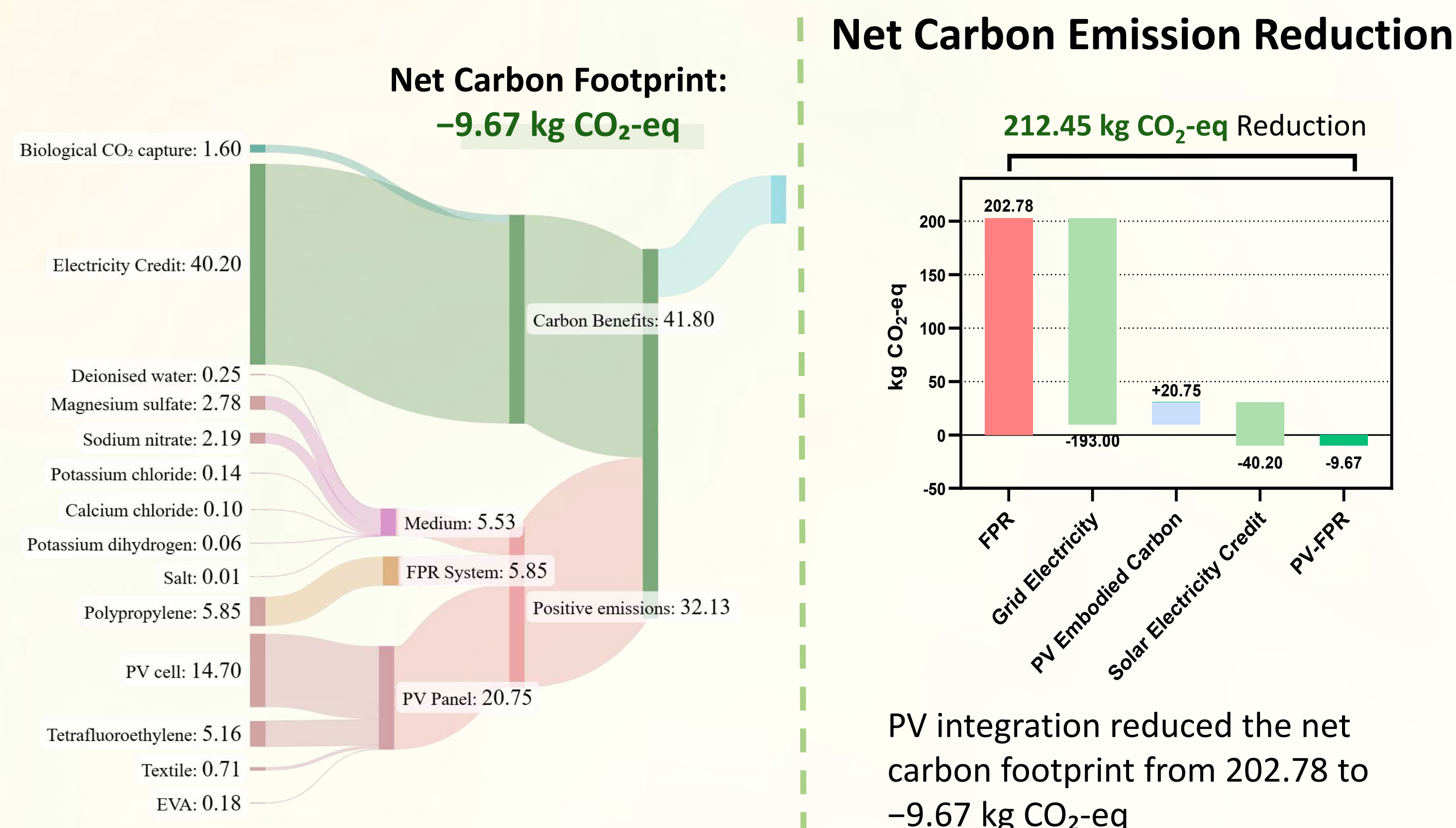
02 PSC Integration: Enhancing Biomass and Carbon Capture Efficiency



03 Optimization: 24-Hour Illumination & Energy Management



Carbon Footprint Analysis of the SSC-FPR System



Conclusion

- ✓ **100%** off-grid operation
- ✓ **1.6 g/L** Biomass production
- ✓ **61.9 %** CO₂ Capture Efficiency
- ✓ **212.45 kg CO₂-eq** Carbon Footprint Reduction

Future Integration:

This micro-scale prototype holds the potential to be integrated into **Building-Integrated Photovoltaics (BIPV)** and smart eco-buildings, advancing **net-zero emission goals**.

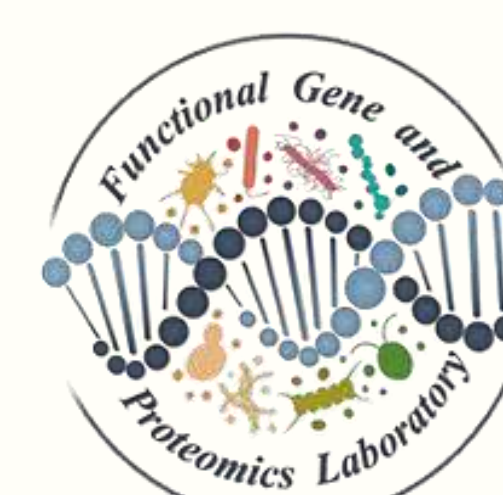
Acknowledgement

¹ NASA Earth Science. Earth Indicators. Retrieved from <https://science.nasa.gov/earth/explore/earth-indicators/>

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Summary:	Ctrl	Capo	PSC-FPR	Light-FPR
Biomass (g/L)	1.0	0.8	1.6	1.3
Glycogen (mg/L)	331.9	76.9	445.8	456.1
Protein (mg/L)	99.8	172.4	84.1	123.0
CO ₂ uptake (g-CO ₂ /week)	3.2	2.7	4.4	4.1
Capture efficiency (%)	39.2	32.7	61.9	50.5