Solar electricity & hot water for dispersed off-grid households in Botswana

Demand-based sizing & Prototype testing initial results

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SolaForm
Innovate UK Technology Strategy Board
EPSRC Engineering and Physical Sciences Research Council

Introducing: SolaFin2go

and an overview of presentation content

Addressing challenges of clean & affordable off-grid modern energy to Sub-Saharan African households

- Solar & Storage providing Electricity & Hot water
- Energy-as-a-service business models for the “unbanked”

1) Botswana country context
2) Household energy demands
3) System size & cost
4) Concept prototype
5) Initial laboratory tests
6) Jamataka field trial
7) Ongoing & future work

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Solar energy research (Project lead)

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Robust photovoltaic modules for extreme climates

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Fintech PAYG platform based on mobile, cloud & blockchain

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Innovative solar thermal diode water storage heater

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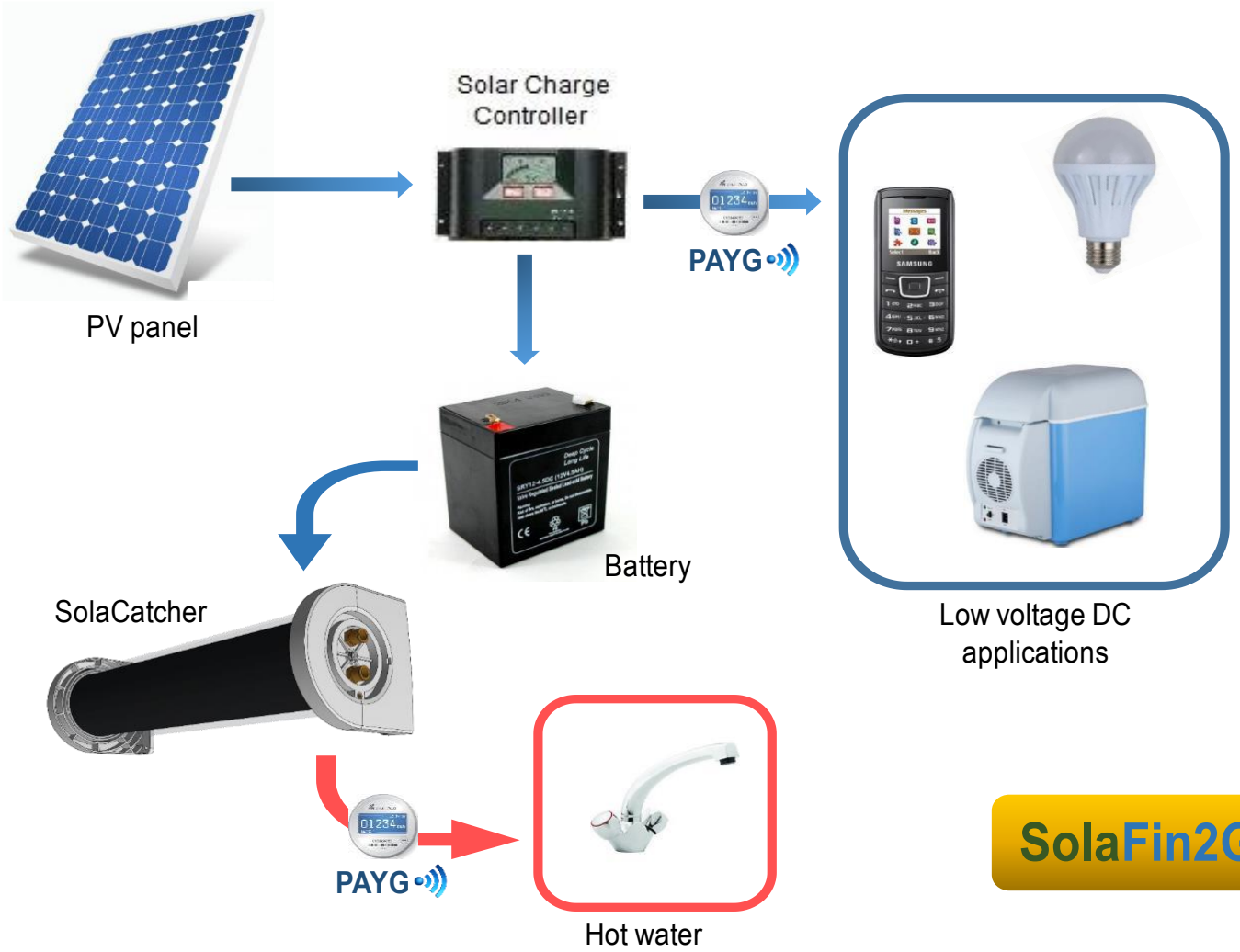
Joint funders
Energy Catalyst Round 5

Innovate UK Technology Strategy Board

EPSRC Engineering and Physical Sciences Research Council

Solafin2go technology concept

Key components



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1) Botswana context

Dispersed rural communities awaiting a national grid that will never come…

Country and population:

- Low-middle income, natural resources, stable democratic government
- Small population (2.5M) in a large land area (size of France)
- Urban populations served by electricity grid (coal fired)
- Dispersed rural populations (>0.5M) unfeasible to electrify with mains grid

Willing & able to pay:

- Many “unbanked” citizens with limited capital and no access to finance, but…
- Rural communities currently pay for dirty fuels, phone charging & batteries
- Government has budget for electrification but favours incumbent “fossil-grid”
- 130,000 households market ($47M) for off-grid solar (*World Bank, 2017*)

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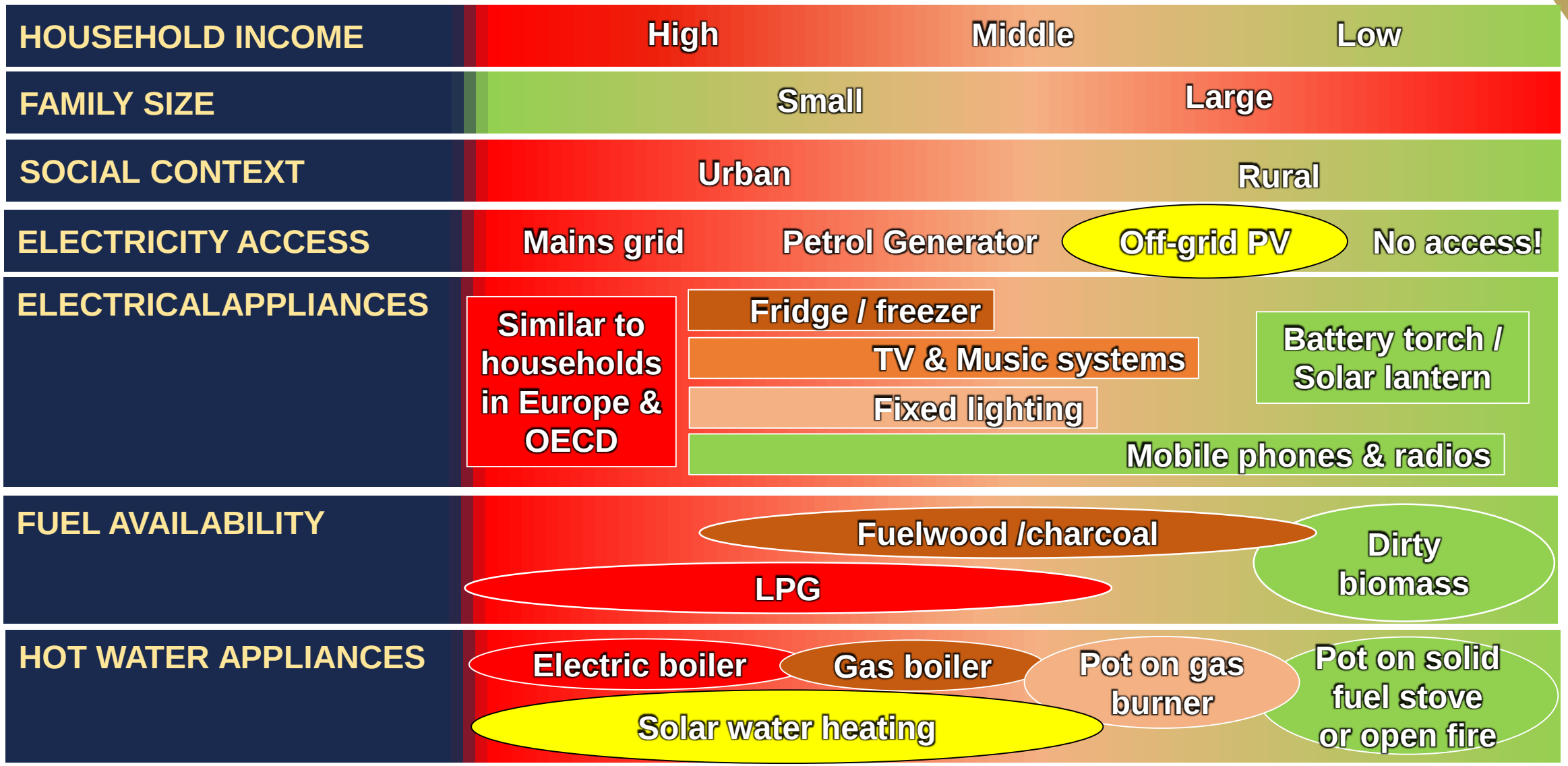
2.1) Household energy demand variables



2.2) Household energy demand in SSA

- ELECTRICITY (kWh/day) [Essah & Ofetotse, 2015; IEA, 2014; Prinsloo et al., 2016]
- HOT WATER (kWh/day) [Meyer, 2000; Ferrer, 2017; Curry, 2017]
- COOKING (kWh/day) [Bachelor et al., 2018; Prinsloo et al., 2016]
- TOTAL??? (kWh/day)

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3) System size & cost

What is an “entry level” system?

Meet electricity & hot water demand in low/mid income off-grid households:

- 0.8 kWh/day electricity (lights, TV, phones, maybe small fridge)
- 1.1 kWh/day hot water (equivalent 20 litres at 65°C)

Affordable for users & viable for investors:

- Capital cost target ~ £600
- End user cost ~ £25/month enables ROI after 2 years
- Modular & upgradable to meet changing (increasing) user demands
- BATTERY COST!!!

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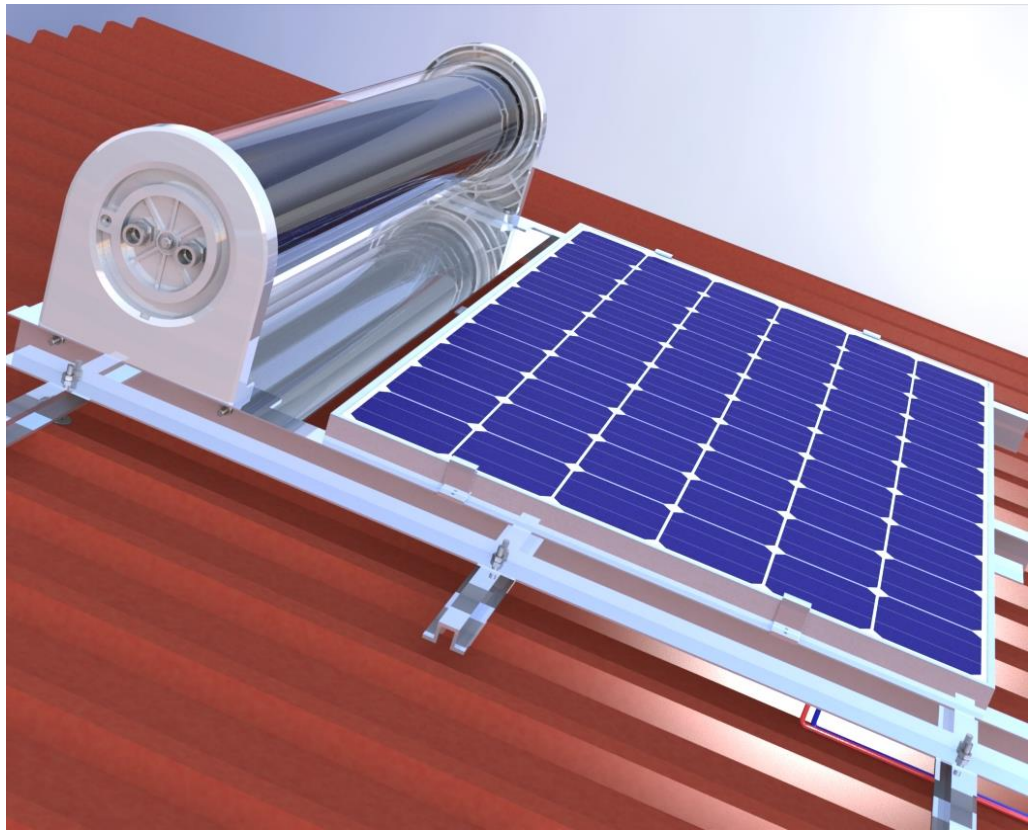
4.1) Prototype development

Key components and concepts



- Standard size PV modules (60-cell @ 275Wp) for optimum cost-benefit
- Battery sized for autonomy in typical periods of cloudy weather (125Ah @12V)
- 30 Litre integrated-collector-storage "*Solacatcher*" solar water heater with heat retaining thermal diode
- Controller (MPPT): manage battery charging & loads & utilise surplus electricity to boost hot water production
- Communication: energy consumption and system status reported to cloud via LoRaWAN & mobile phone network

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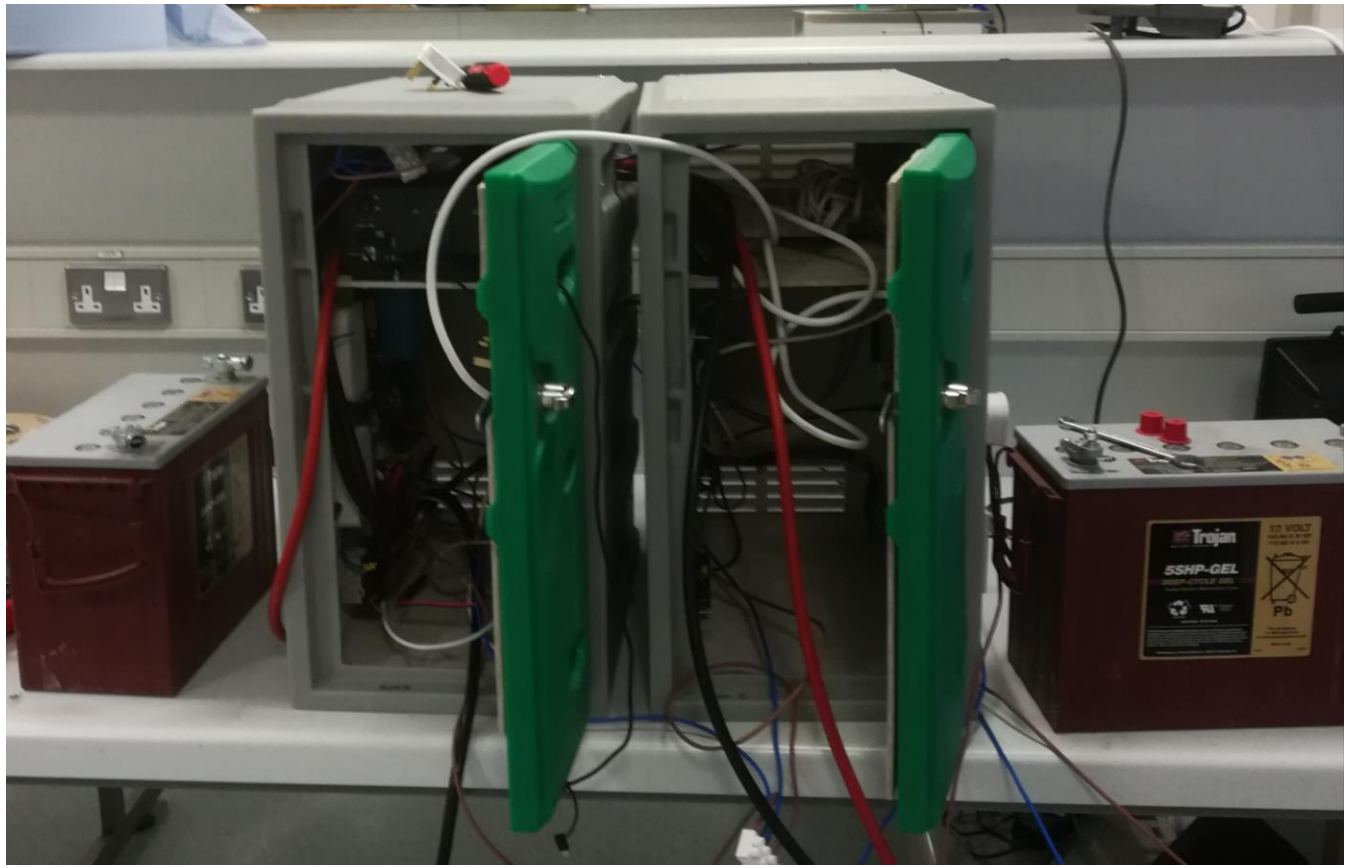
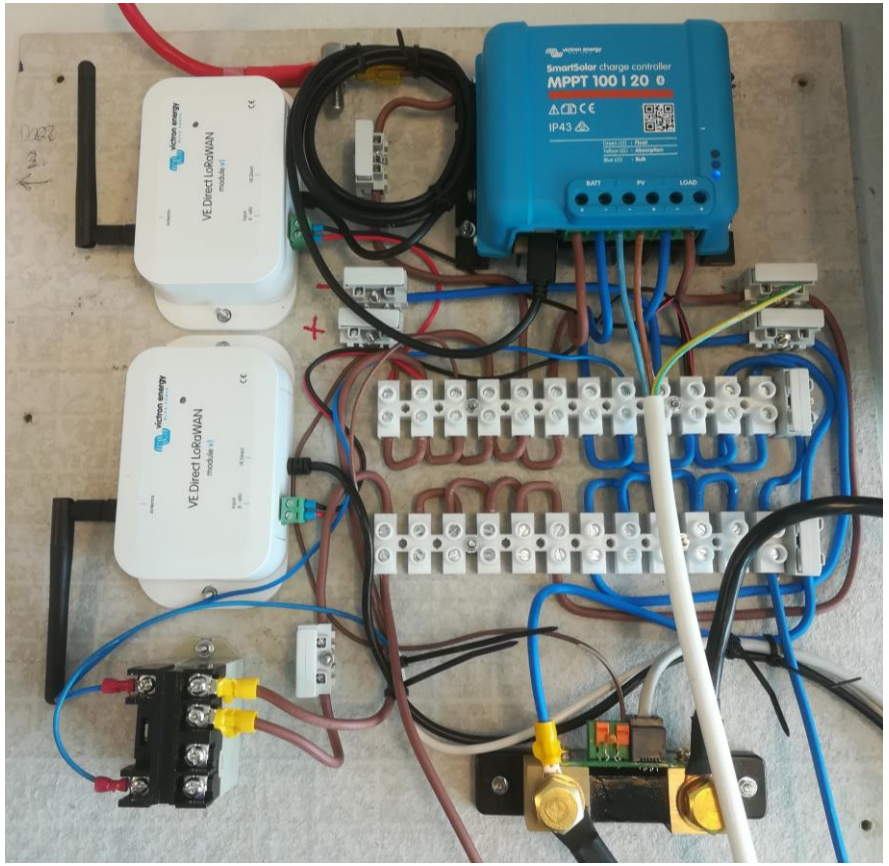
4.2) Prototype development

Batteries, controllers & communications





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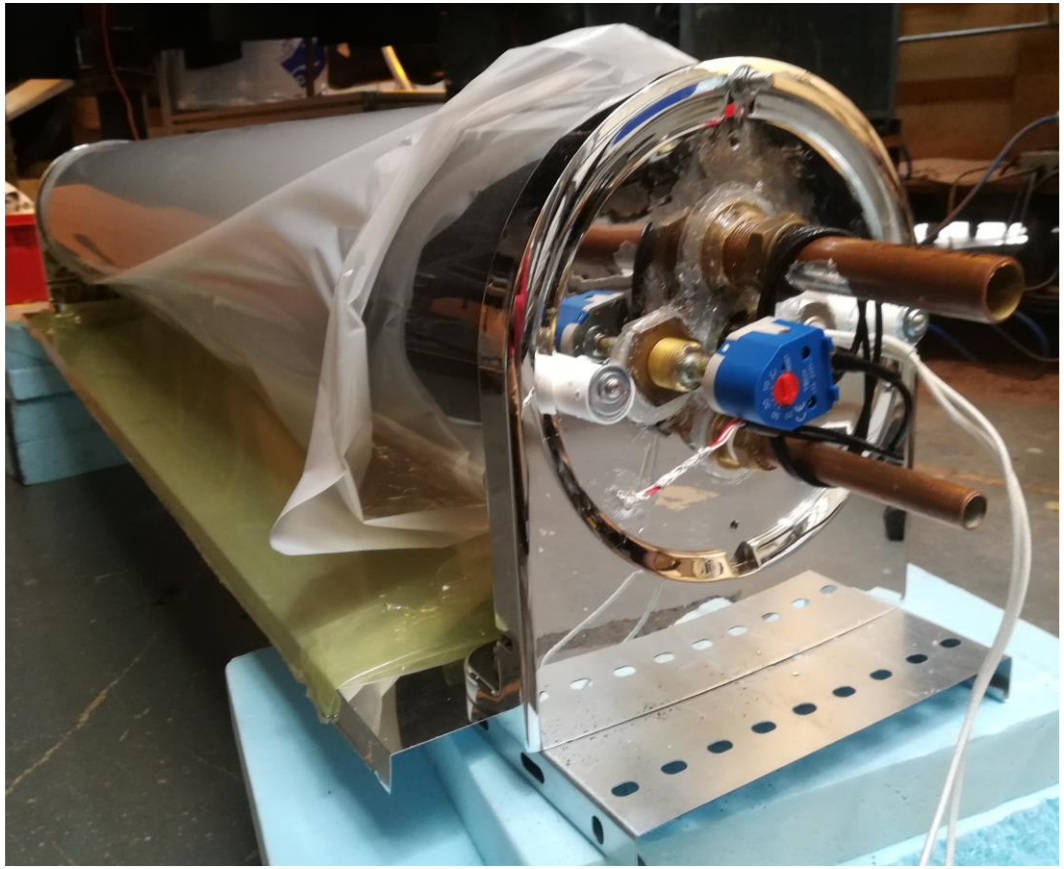
4.3) Prototype development

Solacatcher fabrication



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5.1) Initial laboratory tests

Setup and test conditions

Start test with:

- Battery at close to full charge
- Water tank full & at ambient temperature

Test for 48hr period:

- 8 hr daytime (6 kWh/m^2)
- Simulated solar irradiance ~750 W/m^2
- No electrical load except immersion heater
- No hot water draw-offs
- 16 hr darkness to assess overnight heat retention

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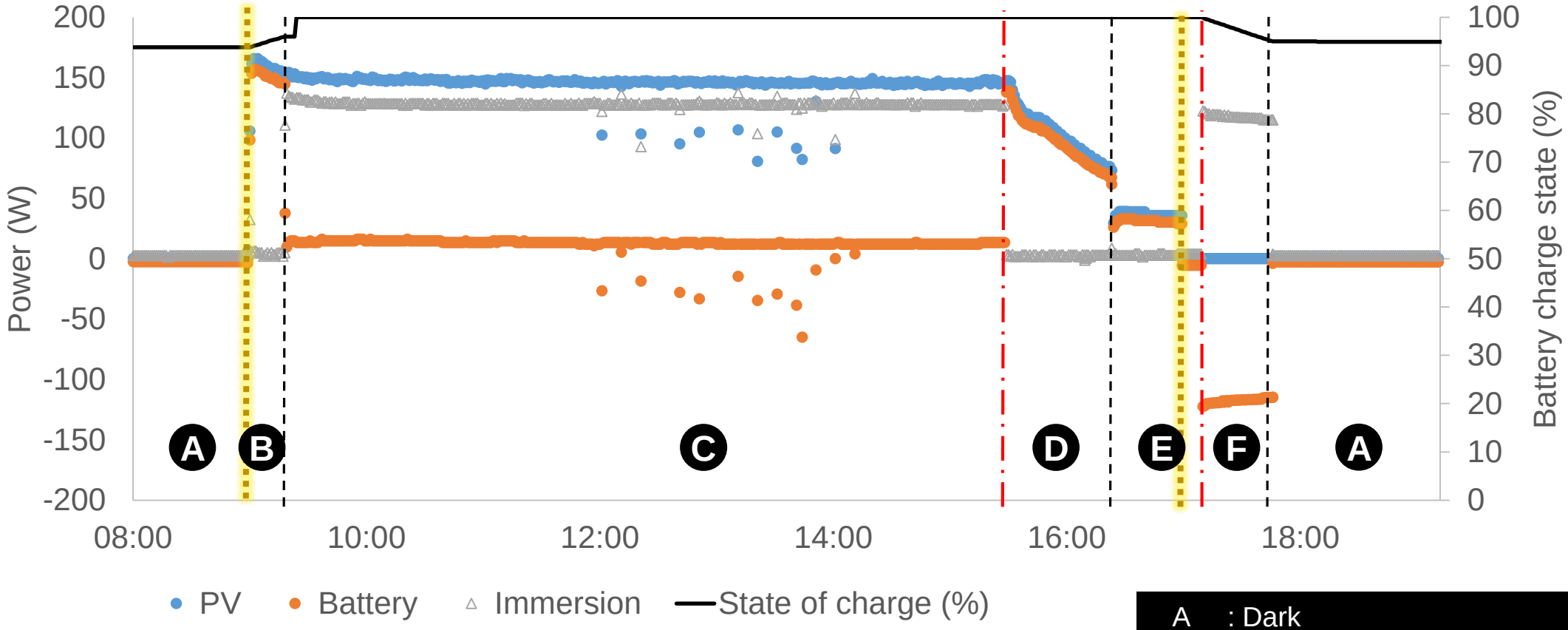
5.2) Initial laboratory tests

Electrical results



A : Dark
B→E : Simulated sun
A & B : Immersion off (auto)
C & F : Immersion on (auto)
D→E : Immersion off (manual override)

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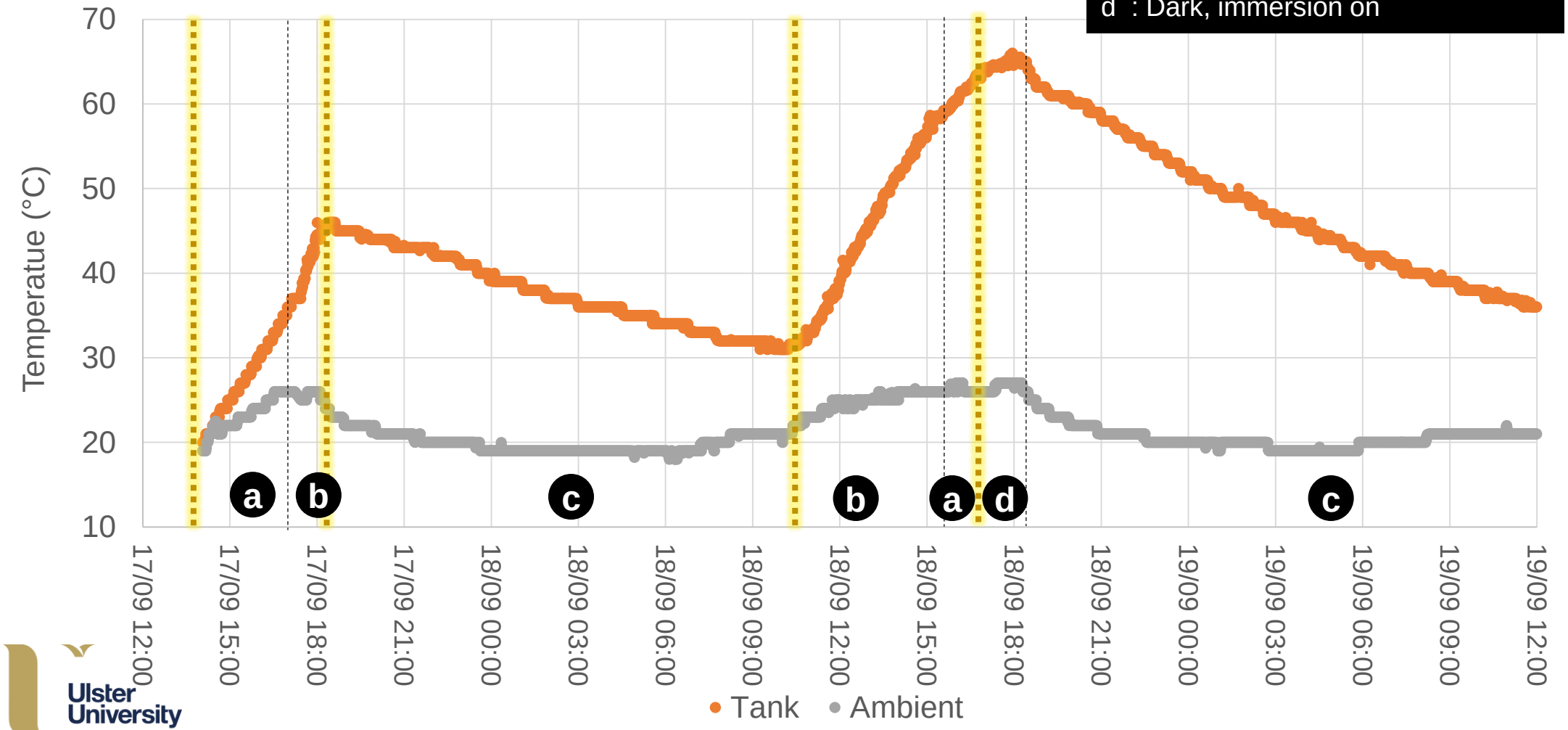
5.3) Initial laboratory tests

Thermal results

a : Simulated sun, immersion off
b : Simulated sun, immersion on
c : Dark, immersion off
d : Dark, immersion on



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6) Jamataka Field trial

Prototype installation October 2018

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7) Ongoing & future work

Monitoring and Scaling up

- Feedback from community stakeholders
- Remote monitoring until March 2019 via LoRaWAN and mobile networks

- Energy Catalyst Round 6 funding application
    - Scale-up by installing more systems
    - Organic formation of a prosumer mini-grid network
    - Community empowerment via local DESCo
    - Financial de-risking through business model testing

- Jamataka showcase “solar village”

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Thank you for listening

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