FUTURISTIC BEEHIVES FOR A SMART METROPOLIS

Deliverable D2.2

Power supply and storage system of the hive

Lead Beneficiary	BST
Delivery date	30.11.2021
Dissemination Level	PU
Version	1.0
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DELIVERABLE SUMMARY SHEET

Project number	824069
Project Acronym	HIVEOPOLIS
Title	FUTURISTIC BEEHIVES FOR A SMART METROPOLIS
Deliverable No	D2.2
Due Date	Project month M32
Delivery Date	30.11.2021
Name	Power supply and storage system of the hive
Description	This deliverable consists of a hybrid power system that powers the electronics embedded in the hive. It includes energy storage (batteries) that buffers the energy harvested from various renewable sources (solar, wind, vibrations etc.) and supplies the stored power to the various embedded electronics in order to make the hive energy independent.
Lead Beneficiary	BST
Partners contributed	-
Dissemination Level	Public

Introduction

Purpose and scope of the document

The purpose of this document is to give an overview of the power storage and supply system developed as part of WP2 and intended to power the electronic and mechanical components of the HIVEOPOLIS beehive. The report is intended to accompany the demonstrator video and to provide additional context as well as extended information of the demonstration that showcases the main functions of the system.

Overview of the document

This document will follow the demonstrator video scene by scene, explaining the setup and the purpose of each step in the demonstrator.

Acronyms and Abbreviations

Acronyms and Abbreviations	**Definition**
PCU	Power Control Unit
RPi	Raspberry Pi
SBC	Single Board Computer

Demonstrator video overview

Power Control Unit

The demonstrator video starts with a brief overview of the Power Control Unit (PCU) - the central component of the Power supply system of the HIVEOPOLIS bio-hybrid (Figure 1). The PCU is a system designed for the HIVEOPOLIS project taking into account the functional requirements of the power supply described in the Functional requirements document created by the consortium as part of Deliverable 2.1.

Figure 1. Power Control Unit (PCU)

The PCU has 16 controllable **output channels** that connect to the inhive systems of the HIVEOPOLIS hive. Each channel can be switched ON and OFF, can detect open load (i.e., no system is connected to the channel), has short circuit detection (i.e., a malfunctioned system or powerline issue), the current draw on the channel can be measured and an adjustable current limit can be set. In case overcurrent detection is triggered, the respective channel is automatically switched off to prevent damage to the system, the power supply or the hive as whole. In addition two the 16 controllable channels, the PCU has two always-on channels intended to power the Central Core single board computer and any additional system that would not need to be switched off.

The PCU provides 12 Volts on each channel - the highest voltage that systems designed as part of the project require. Systems that require lower voltage levels will be responsible for regulating the voltage level locally.

The PCU has two **input channels.** Each input can draw power from either a wall outlet or a battery, allowing the power supply to be used both in situations when utility power is available, and in remote locations. In case both inputs are plugged in and there is a significant current draw from the output channels, power is shared between the two inputs. Each input can be disconnected and the system will seamlessly switch to the other input, allowing uninterrupted operation of the system. This is important in cases such as the electricity supply going down, or one of the batteries being fully drained .

The PCU connects to the Central Core SBC over USB, providing control of the power routing.

Power Supply System

The PCU is the central component of the Power Supply system - the next scene in the video (Figure 2) is intended to provide a schematic overview of demonstrator setup.

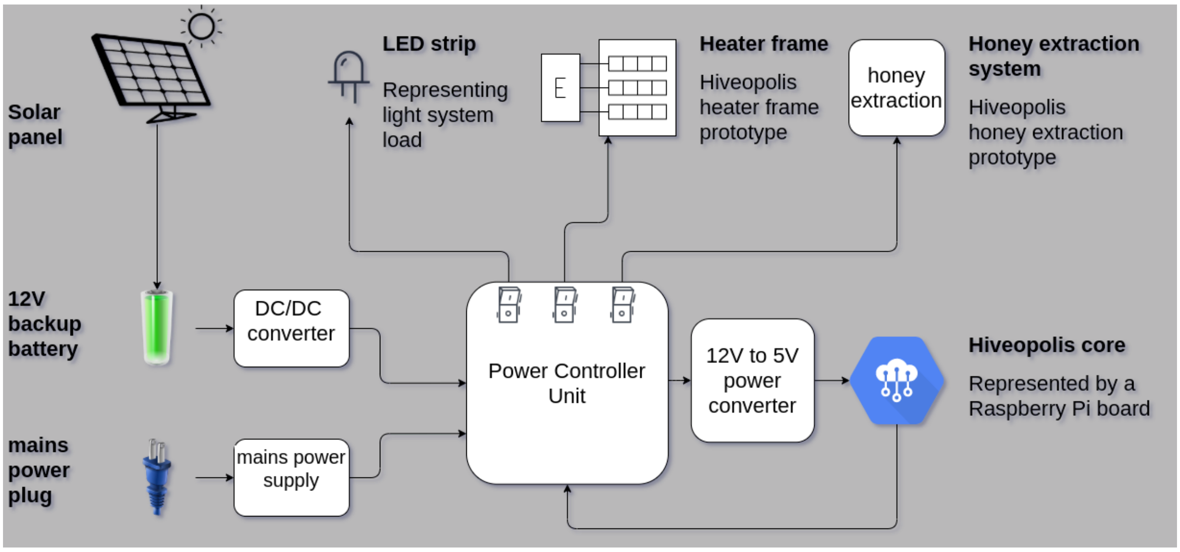

Figure 2: Power supply system

On the input side the video shows both input channels being used - a 50 Ah Lithium battery is connected to one of the inputs and a 12 Volt power supply connected to the grid is plugged into the other channel. The solar panel and charging system are not shown in the video as they consist of off the shelf components (solar panel and solar charge controller).

On the output side 4 power consuming systems are demonstrated, most of them with HIVEOPOLIS prototypes where possible:

- A **led strip**, acting as a replacement for a low power HIVEOPOLIS system (e.g. a sensor or actuator that has a small current draw)
- A **heated frame -** an early prototype developed by EPFL as part of WP5, representing a system with a more significant current draw
- The **Honey extraction system** prototype developed by BST in WP6

- The **Central Core** single board computer (Raspberry Pi) that will run the main computation module of the HIVEOPOLIS bio-hybrid. This also demonstrates a system that runs on a voltage level different from the 12V provided by the PCU, regulated locally to 5V with the use of a power converted to match the voltage level required by the RPi.

Demonstrator

The next scene sets up the demonstrator scene (Figure 3) of the video by introducing the setup and helping the viewer make the connection between the components of the system and the schematic overview presented previously. The screen in the lower right corner of the scene shows the commands being issued to the PCU and the responses and events detected by the system.

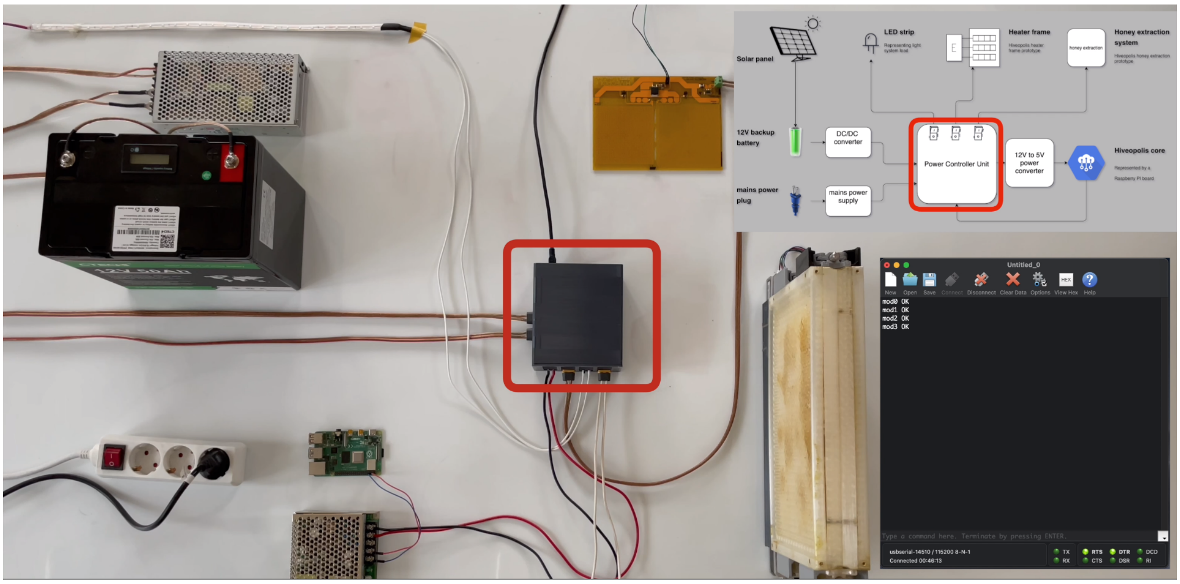

Figure 3: Demonstrator Scene

The demo starts by issuing a command to the PCU to switch on module 0, channel 0, starting the RPi that represents the computation module of the central core. Normally this SBC will be connected to an always-on output channel, and will connect over USB to the PCU, issuing the commands and handling the outputs of the Power control unit. Here it is connected to a regular channel in order to demonstrate the switching functionality of each channel and the commands are issued from a laptop (not shown in the scene in the video). As this is the first load introduced in the system, switching on the RPi triggers a power sharing event that shows that only one input is currently connected.

The next demonstration is switching on the extension outlet to which the mains power supply is connected. Switching on the power triggers another power sharing event, informing the Central Core that the second input channel is up and running.

The next demonstration is sequentially switching on the LED strip, which is intended to represent a light system load (e.g. a low power sensor) and the heated frame, with heating shown with thermal camera footage. Also the "*sys -load*" command is demonstrated that allows the central core to get a snapshot of the input voltage and the current and power draw of all input channels.

The adjustable current limit is demonstrated by applying a current limit of 1000 mA to the channel that powers the heated frame. As was demonstrated previously, heating draws about 1800 mA of current, significantly higher than the set current limit. When the channel is switched on, current ramps up and an overcurrent event is triggered, switching off the offending channel to prevent damage to the powered system or the power supply.

The following demonstration is of the honey extraction system developed in WP6. The channel is switched on and the mechanism of the extraction system is triggered, showing how the cells detach from the foundation so honey can flow out of the cells, and then retract to their original position.

Next an output channel is short-circuited and is triggered - the PCU detects the short circuit and immediately switches off the channel to prevent damage. As can be seen, the rest of the channels continue to operate uninterrupted.

The final demonstration shows switching off mains power, simulating a power outage event. As soon as the extension outlet is switched off, a power sharing event is triggered, informing the core of the change. Again, all systems continue their uninterrupted operation drawing power from the backup battery.

Appendix

Link to the video:
https://youtu.be/mMDqcYg3GEA