

Ottawa Microgrid

Combined Heat and Power Flows and Storage

By
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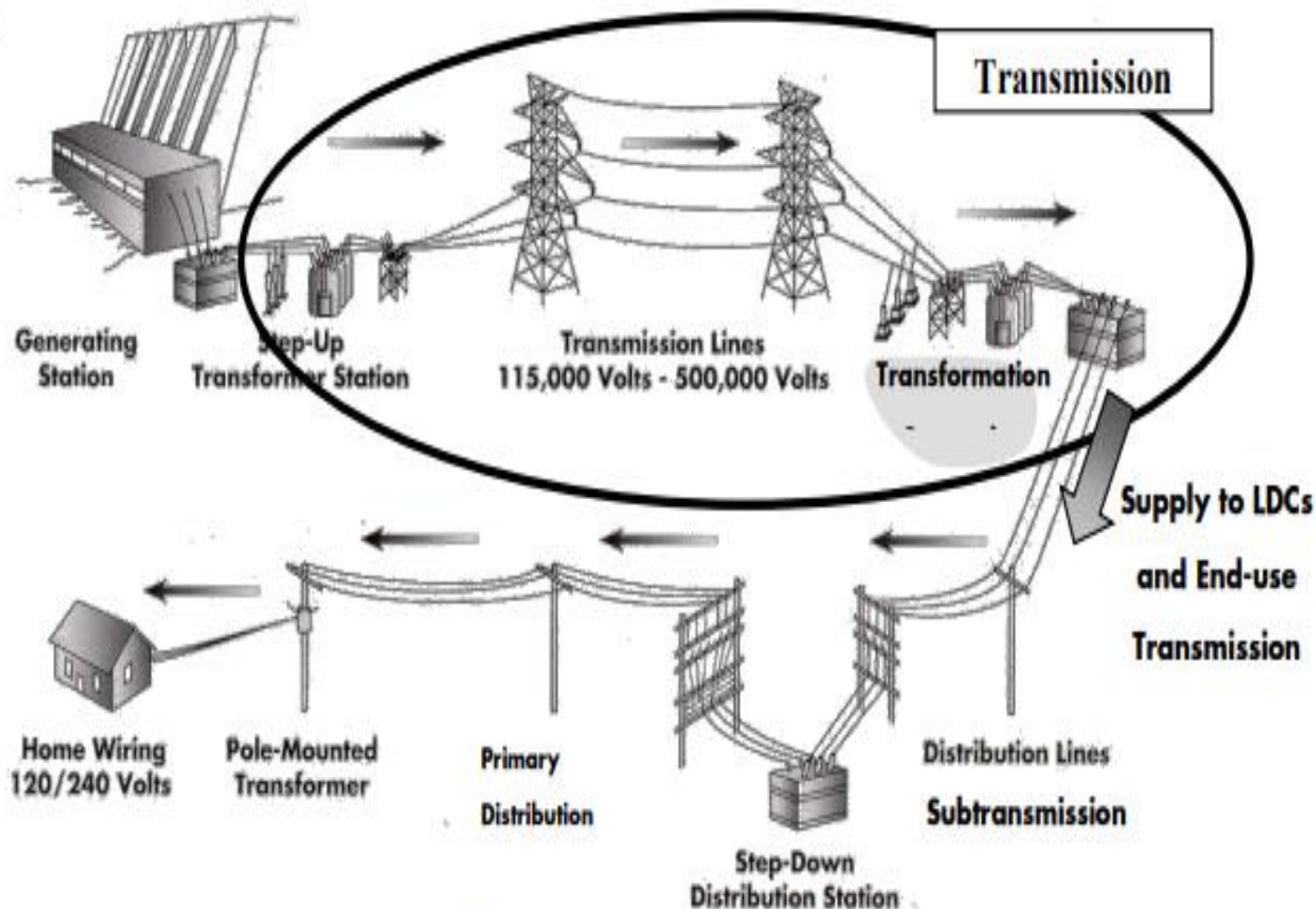
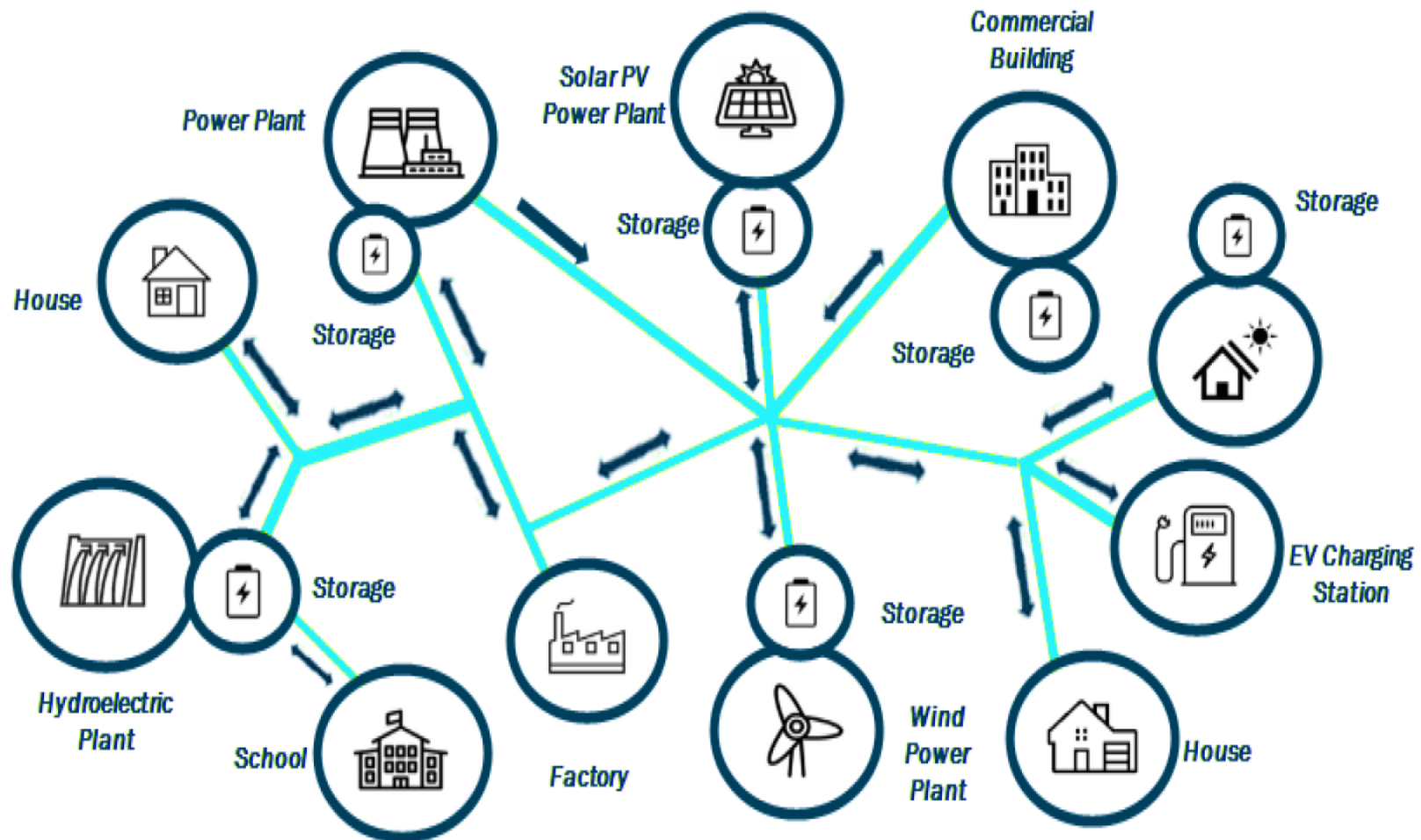


Figure 1: Hydro One Transmission's System³

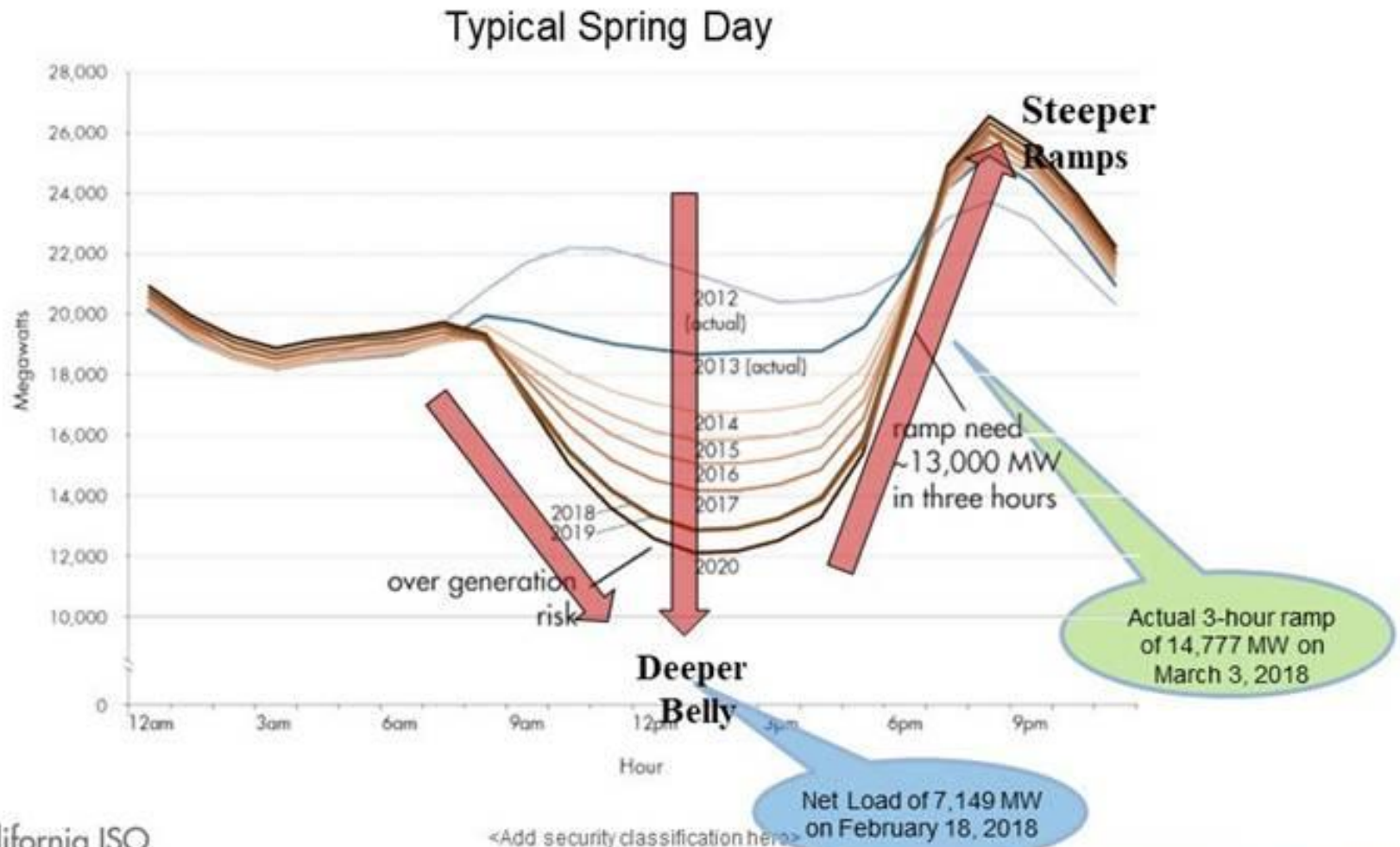


Tomorrow's Grid

Bidirectional flow of Electricity



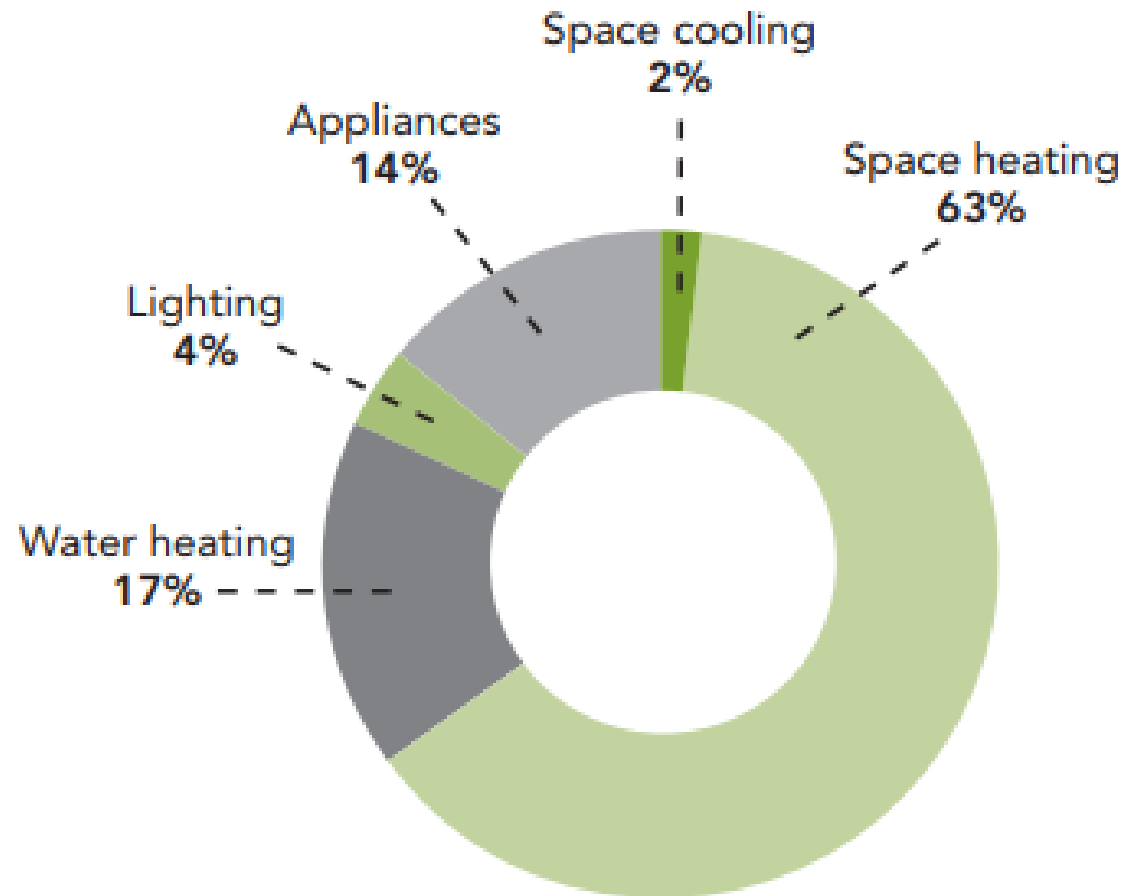
Actual net-load and 3-hour ramps are about four years ahead of ISO's original estimate



What is a Microgrid?

- A small energy network of one or more electricity consumers with a local source of supply and storage that is usually attached to a centralized public grid but is able to function autonomously behind the meter with sensors, meters, data acquisition and optimization controls.
- “By 2020 microgrids could provide between \$64 billion and \$171 billion in electricity cost savings to commercial companies in 20 countries.” Customer loss - termed “grid defection”.

Canadian household energy use by end use



Source: OEE Energy End Use Data Handbook, 2008

Energy Freedom Project

- 5 kW Net Metering rooftop photo voltaic (PV) generation array (20 panels)
- 10 kW microFIT rooftop PV generation array (39 panels) virtually limitless power of the sun
- Three Tesla PowerWall 2 AC batteries for 39 kWh storage
- A Mitsubishi Electric Vehicle (EV) with 14 kWh battery and Level 2 (30 amp) charging station
- A Nest E thermostat
- Control room with three workstations (software development, soldering table and operator position), displays and computer assets.





Energy Freedom

Charging



POWER FLOW



BACKUP HISTORY



CUSTOMIZE



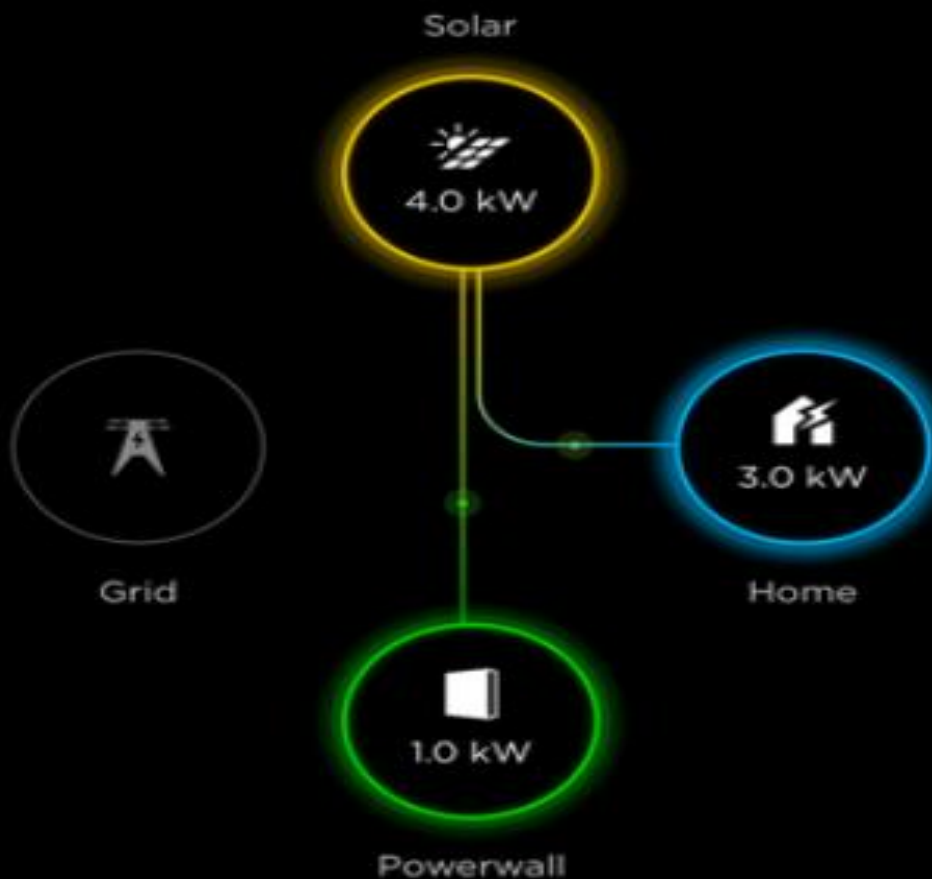
Carrier

9:41 AM

100%



POWER FLOW

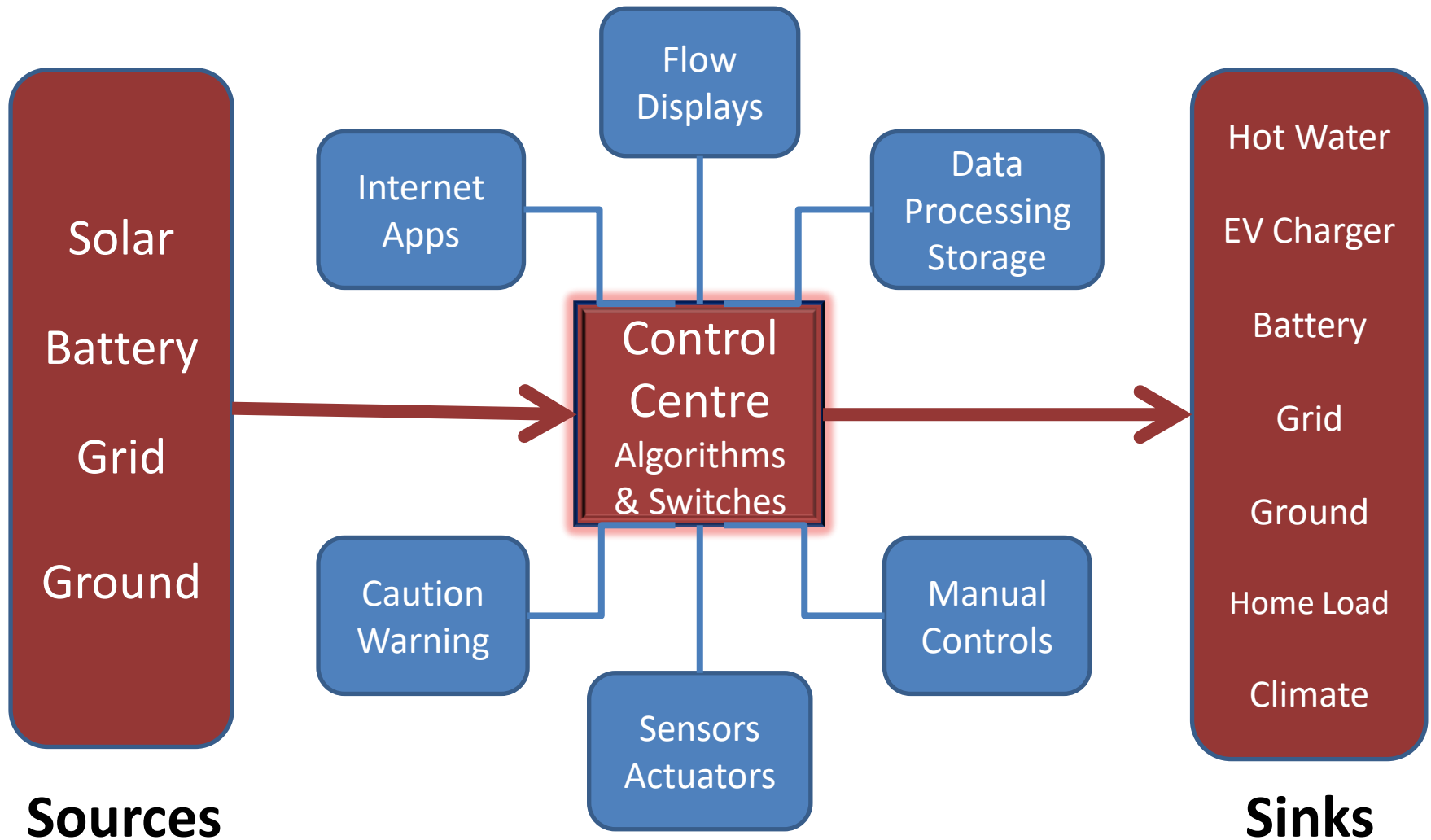


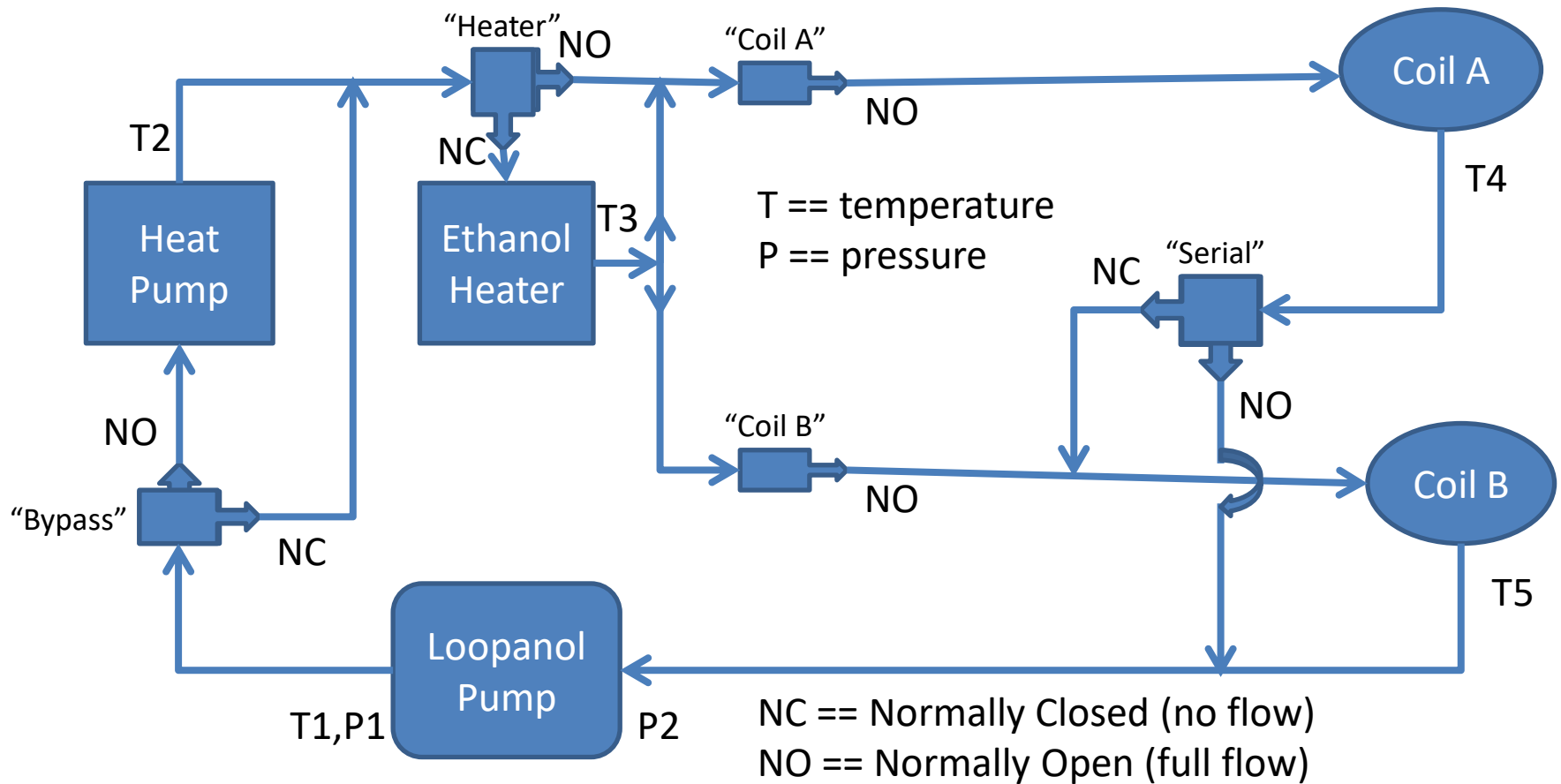


POWER FLOW



Energy Flow Architecture





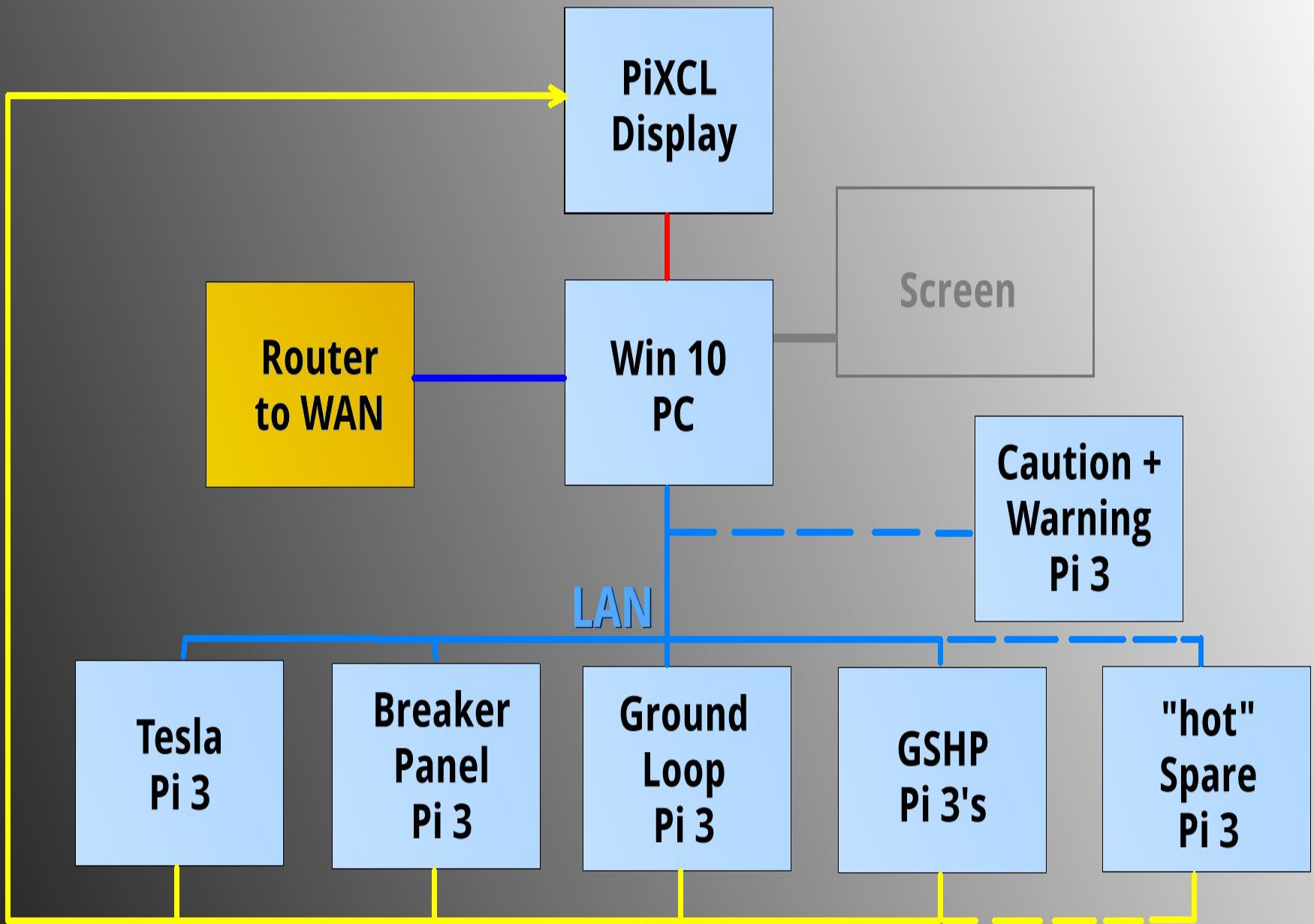
Ground Source Heat Pump Loop Flow Diagram

With and without extra ethanol heating

Parallel flow thru Coil A or B or A+B

Serial flow thru A+B





Software Development Sequence

Software Development Sequence

* Analysis

what is the problem to be solved?

Software Development Sequence

- * Analysis

- * **Design**

How can this be solved in hw and sw?

Software Development Sequence

- * Analysis

- * Design

- * **Testing**

**Predict expected results,
warnings, error conditions.**

Software Development Sequence

- * Analysis

- * Design

- * Testing

- * **Deployment**

Gather real operational case data

Software Development Sequence

- * Analysis
- * Design
- * Testing
- * Deployment
- * **Evaluation**

Did this work as expected?

Improvements? Now what?

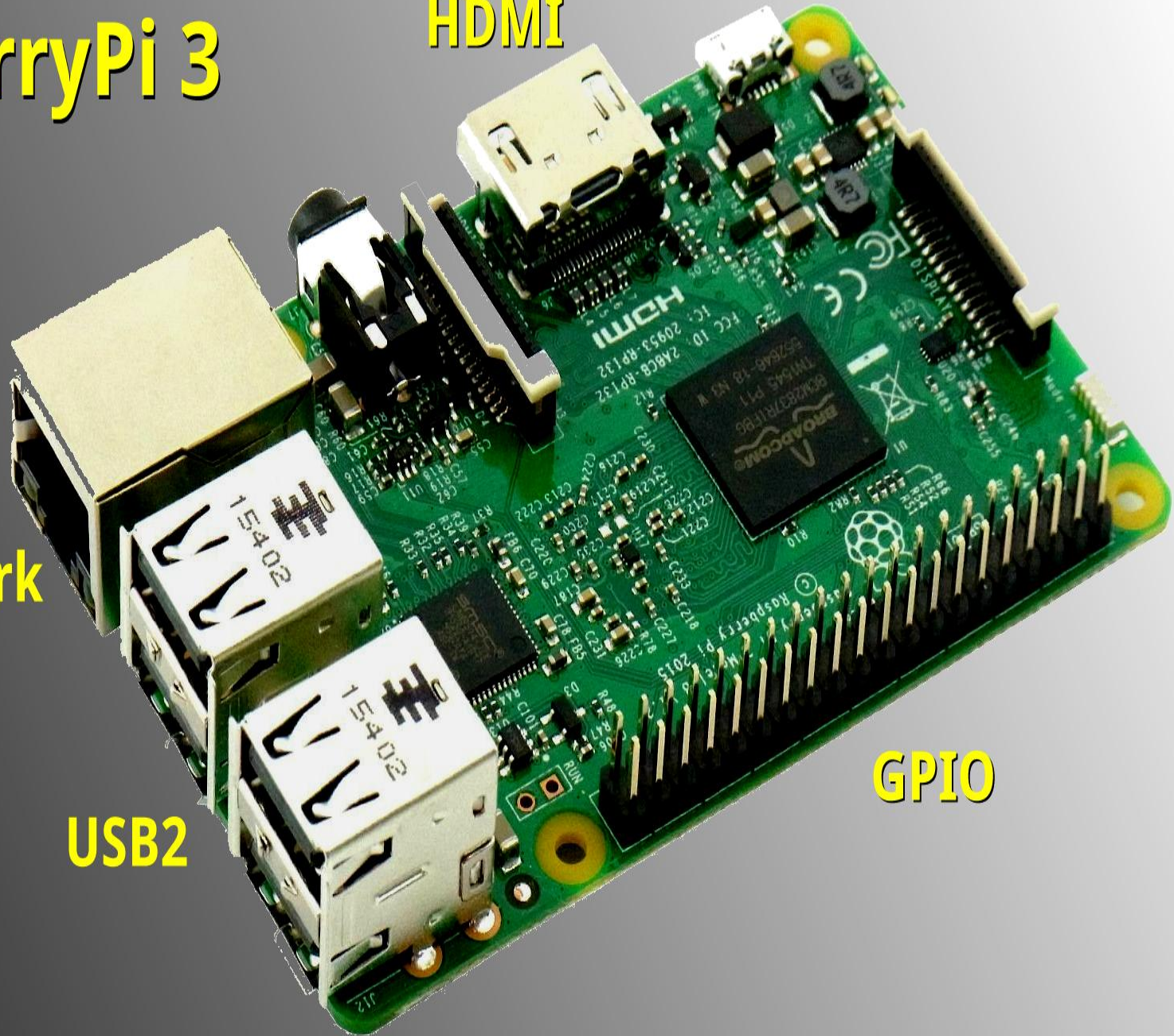
RaspberryPi 3

HDMI

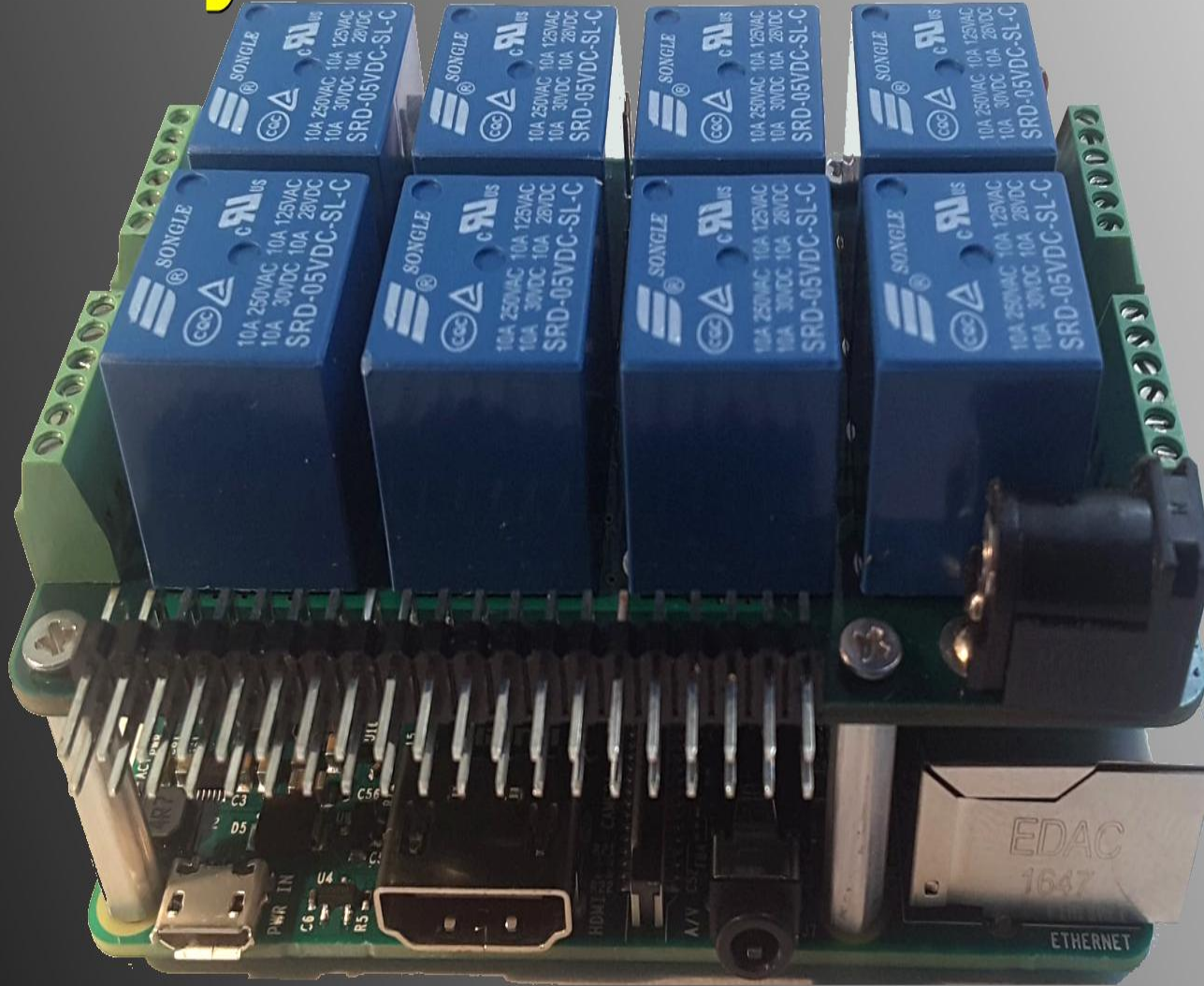
Network

USB2

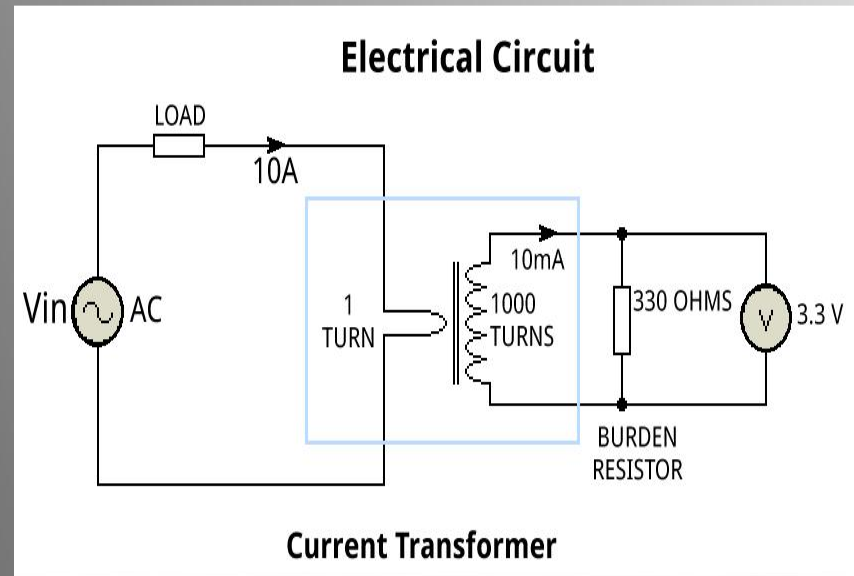
GPIO



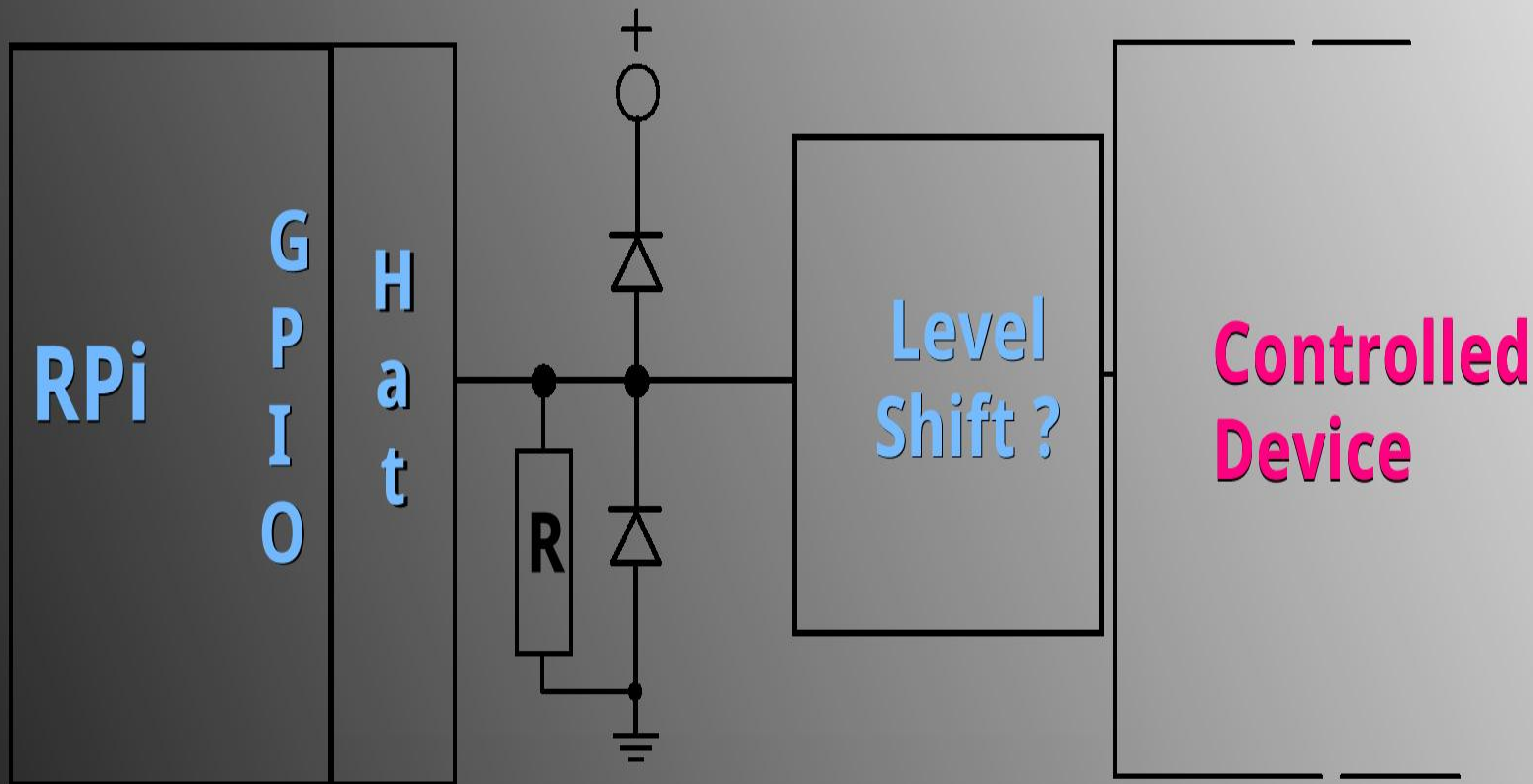
Relays and I/O hat



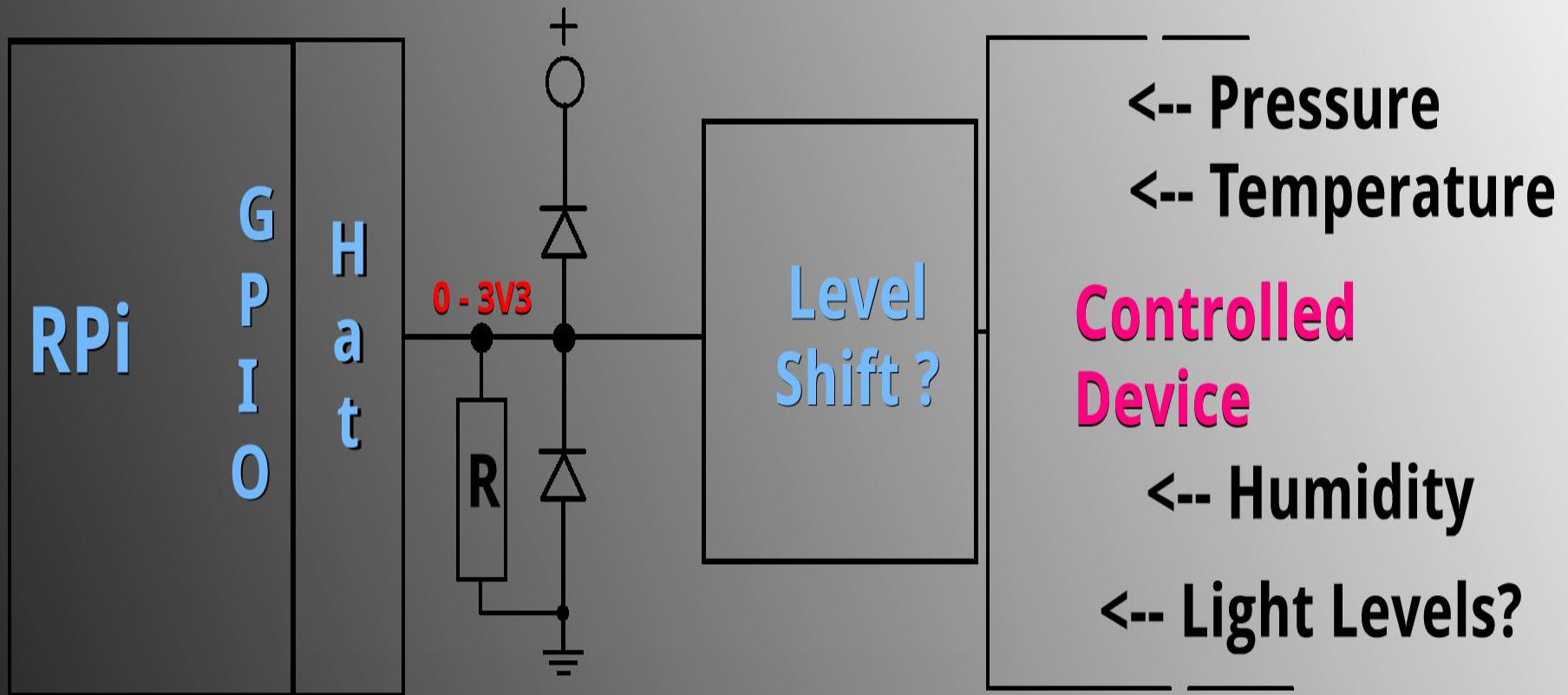
Measuring AC Current



Handling Analog Inputs



Handling Analog Inputs

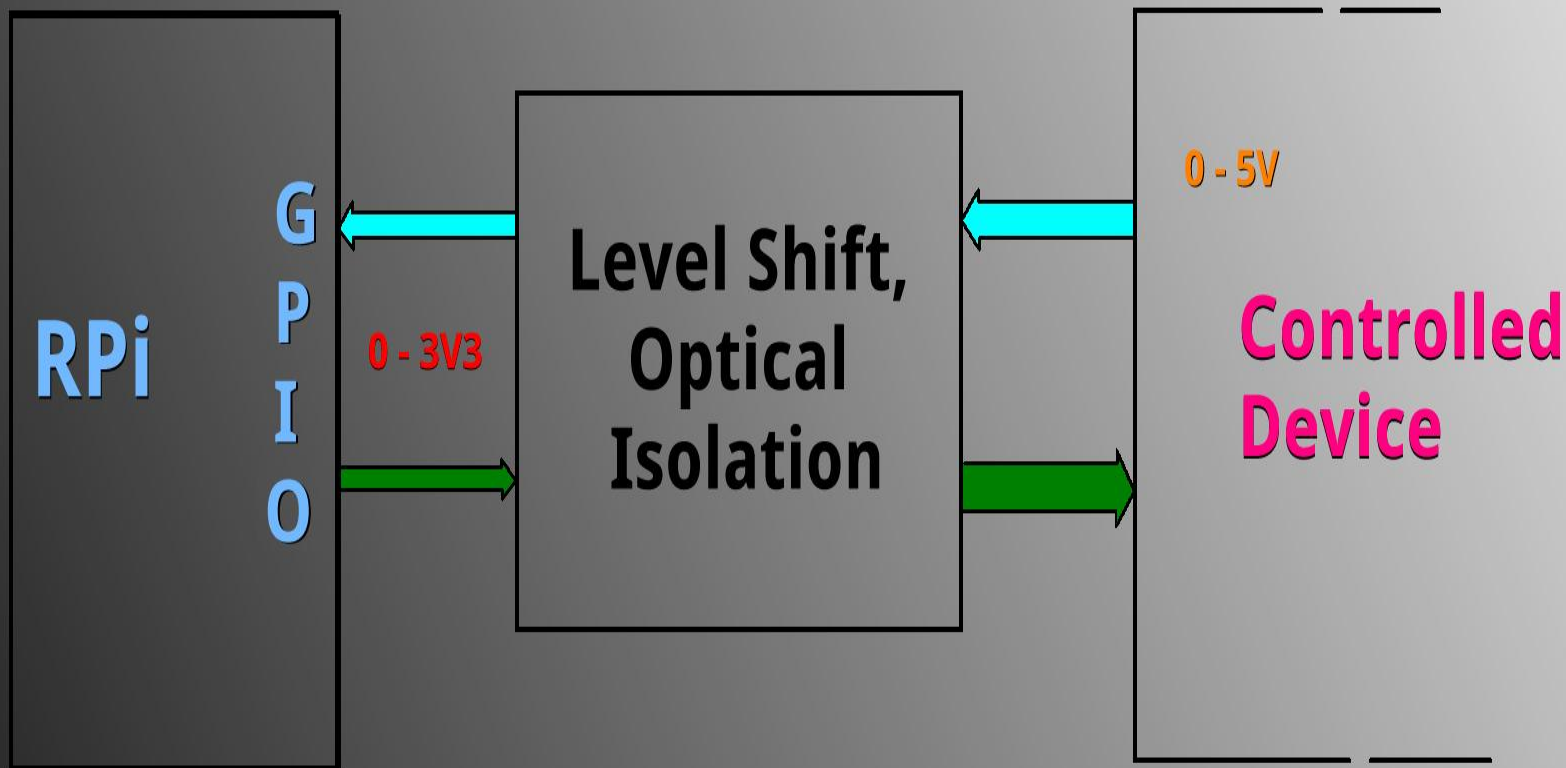


Networked CTs

- * magnitude, direction
- * LAN connection
- * data packets

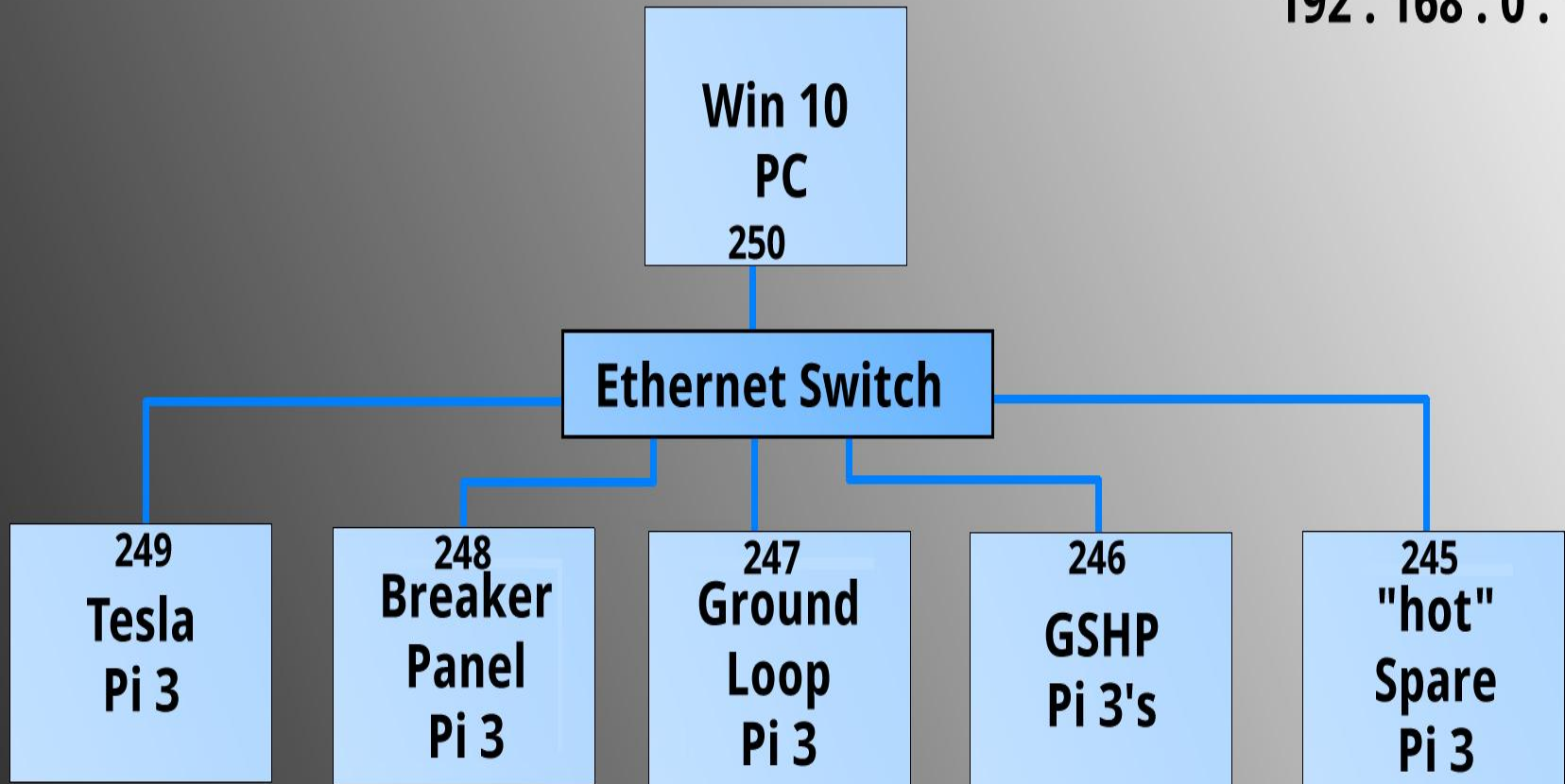


Handling Digital Input and Output



Microgrid Local Area Network

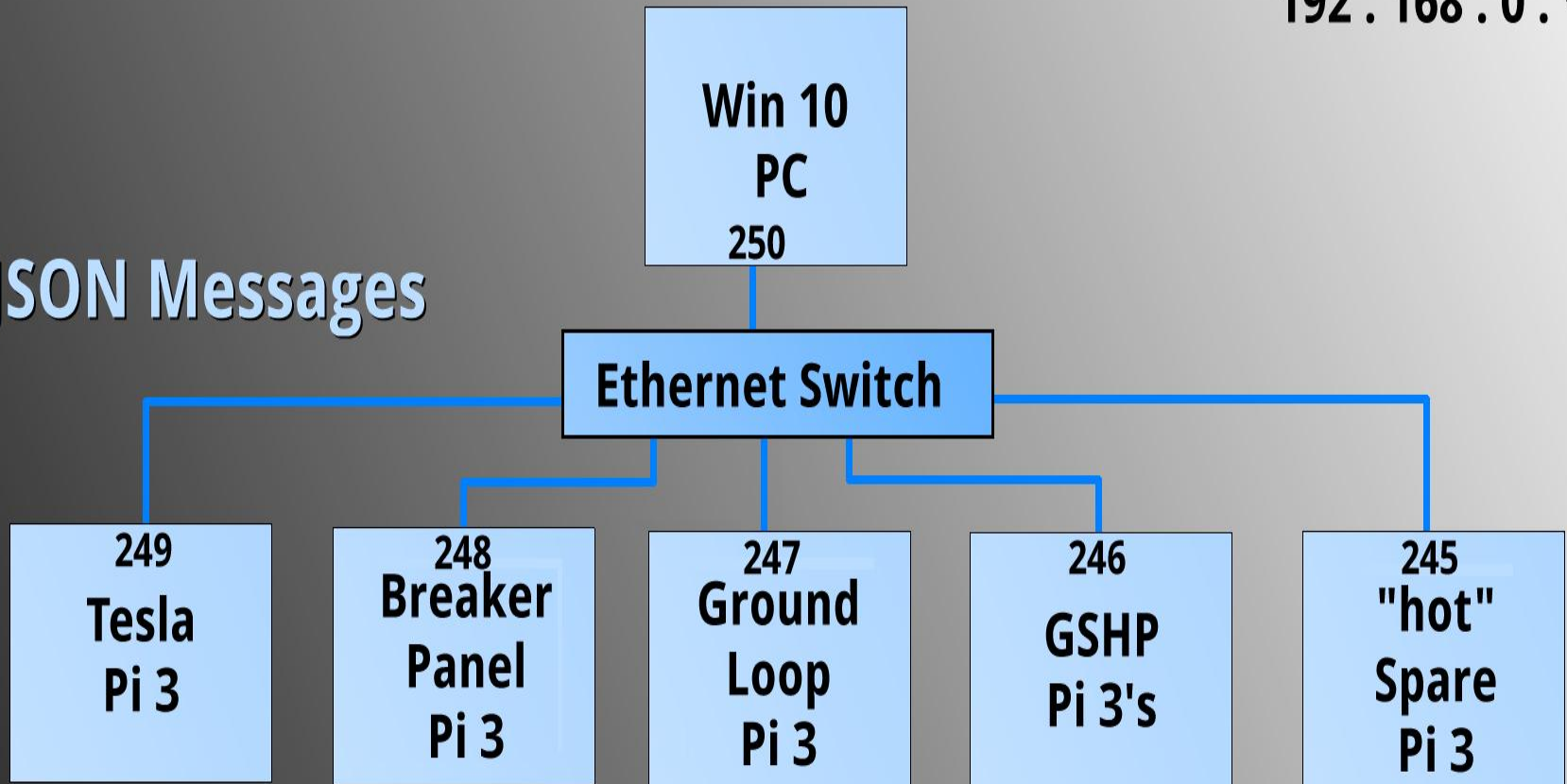
192.168.0.*



Microgrid Local Area Network

192.168.0.*

JSON Messages



Microgrid Status Display

"live" RPi 3
status



IOC-370 Display

USB

**Win 10
PC**

**Primary control
algorithms**