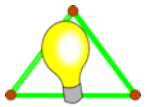
Open DC Grid Project

2021 May



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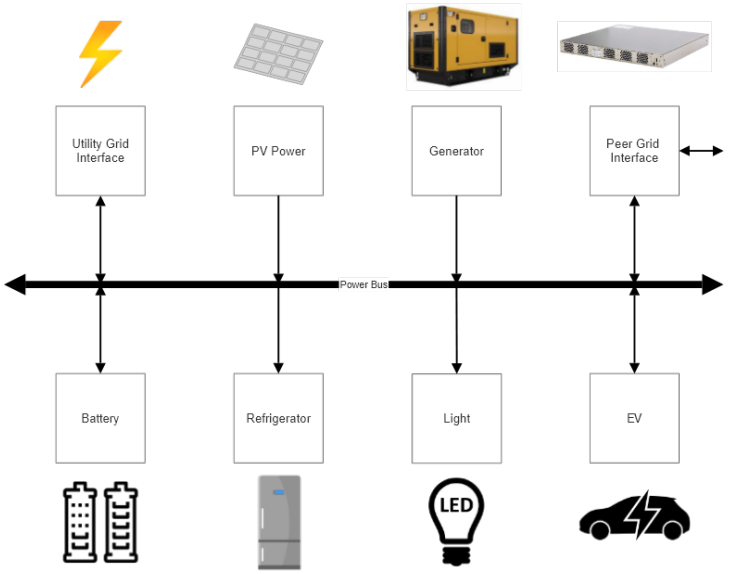
Agenda

- Introduction to Nunam
- Architecture
  - Overview
  - Protocol details
- Related Standards / Industry Developments

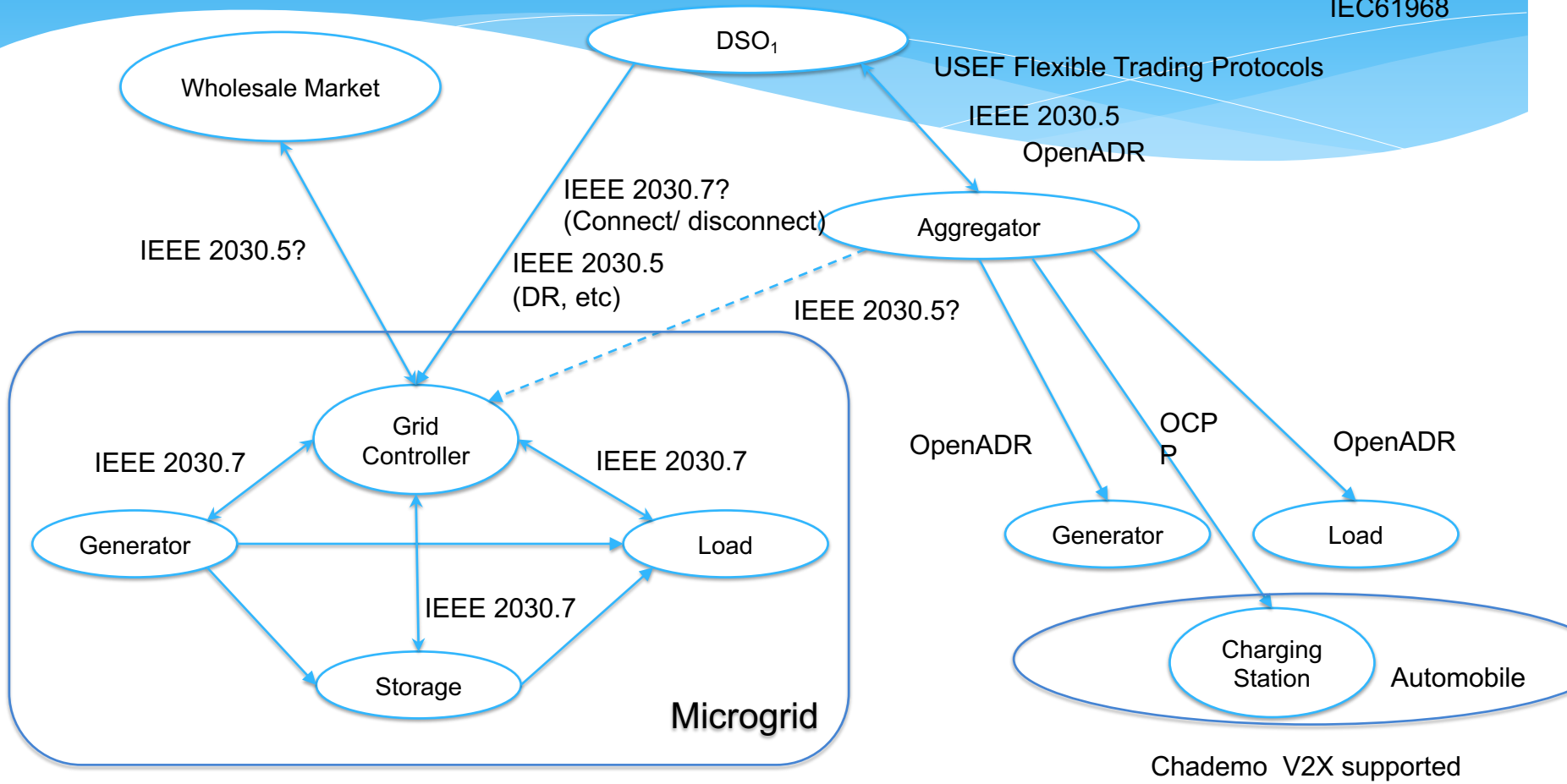
Goals of ODG Standard

- Market of plug-compatible devices
  - Focus on OEM manufacturers over end users
  - Operator choice of open or locked
  - Wide application – not just buildings
- Architecture independent of physical layer
  - Defined for 12V, 48V DC buses
  - Future/maybe: higher voltage DC, AC
- Assumes digitally managed power
  - Managed devices communicate
  - Provision for unmanaged devices
- Operates standalone or connected
  - Neither Internet nor utility grid required
  - Optional remote management, AC interface
  - Defaults to autonomous operation
- Suitable for energy access markets
  - Very low cost to conform to ODG
  - Safe, easy to understand, plug & play



ODG Consistent with Other Microgrids

Any relation?
DNP3
MltiSpeak
IEC61968



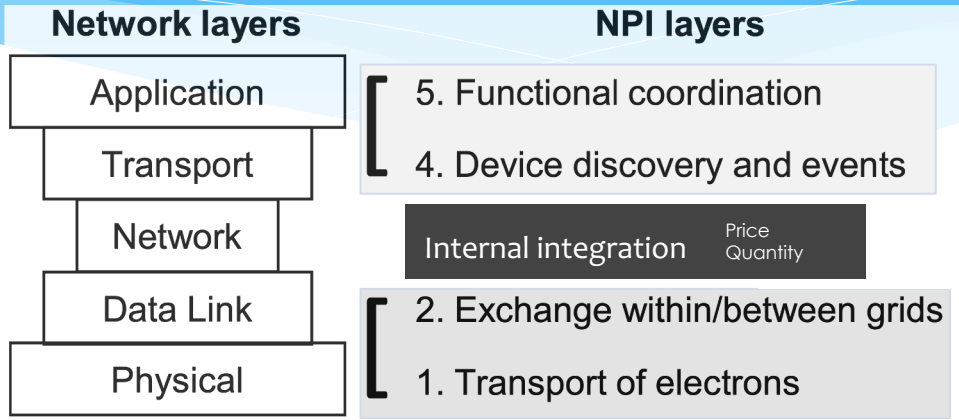
From Kotaro Jinushi, Sony CSL

Chademo V2X supported
Charin Not yet V2X
GB/T Not yet V2X
Teslar Not yet V2X

1 DSO: Distribution System Operator

Design principle 1: Layering / Network Power Integration (NPI)

- NPI is derived from and has similarities with the OSI model
- It doesn't replace OSI
  - It operates in parallel
- Goal: Separate network mechanism from details of specific physical layer tech.



- In communications, the narrow waist is a protocol
  - In power, it is price and quantity of power over time
- Price and quantity can be used at the building/grid interface and within a building

Adopt NPI as a basic architectural principle

From: Shuli Goodman, LFEnergy, Bruce Nordman, LBNL

Design principle 2: Digitally Managed Power

- Most communications have moved from analog to digital in the past half century
- Power will likely do the same
- Investing LFE effort in legacy analog power distribution - **in buildings** - may be a waste
- Works best with DC, but can also be applied to AC systems
- Can be link (2 devices) or bus (>2 devices)

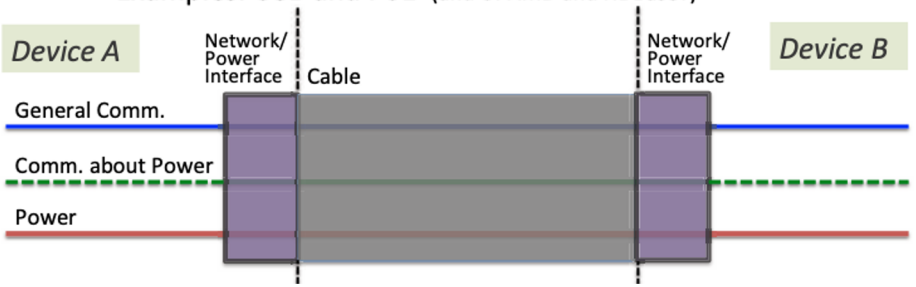
"Standard DC"

A method for transmitting DC power defined by a well-known technology standard, enabling plug-and-play interoperability

"Managed DC"

Standard DC technologies that include communications for managing power distribution within the power cable & connector

- Over the power wires or over adjacent wires
- Examples: USB and PoE (and UPAMD and HDBaseT)

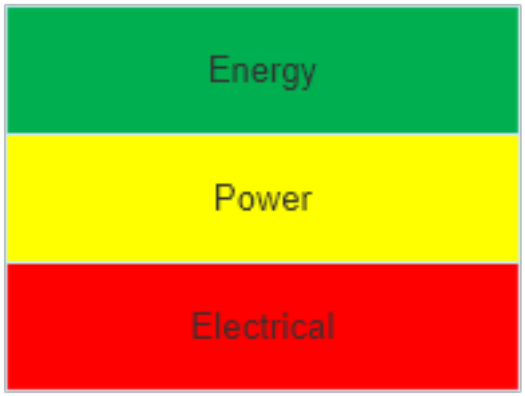


Focus effort only on Digitally Managed Power (no more stupid plugs)

From: Shuli Goodman, LFEnergy, Bruce Nordman, LBNL

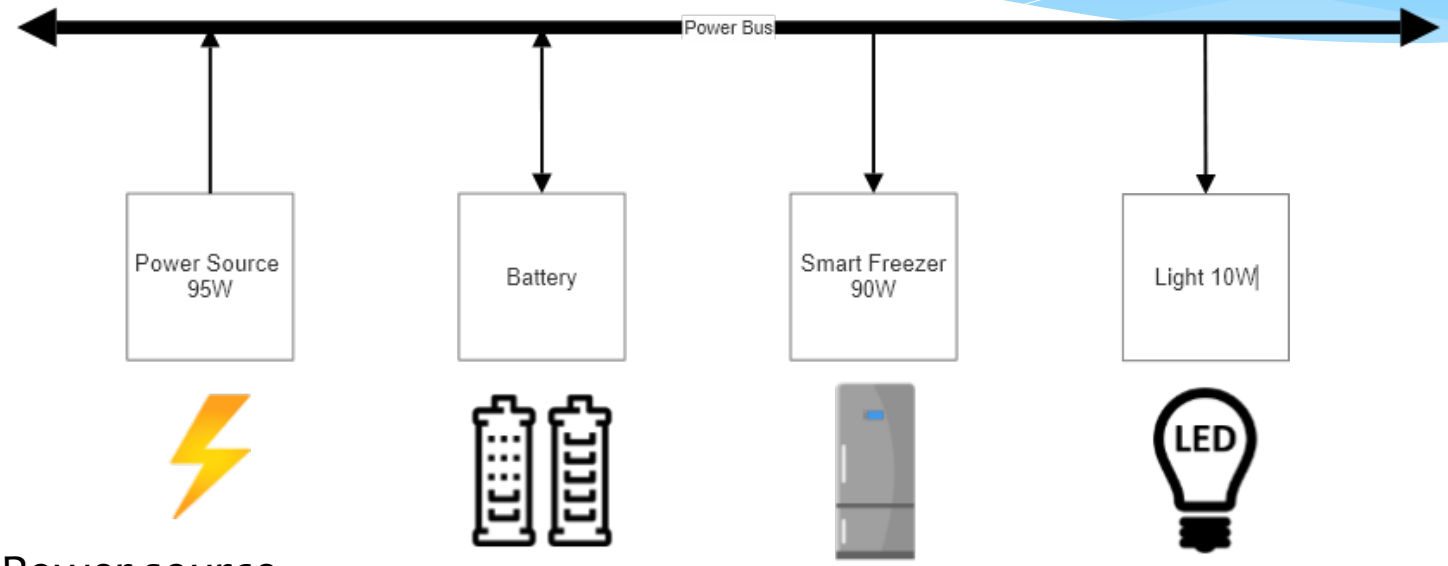
Microgrid Management Layers

* Energy
  * Time scheduled energy flow
  * Optional in any microgrid – perhaps specific devices
  * Loosely defined by ODG, proprietary implementations
  * Slow response times (roughly minutes to hours)
* Power – required in sources, optional in loads
  * Core functionality in all sources
  * Behavior narrowly defined, conformance tests
  * Human response times (roughly 1-500 ms)
* Electrical – present in all devices
  * Voltage, current setpoints, ranges, limits
  * Source impedance (droop curves)
  * Fast response (roughly < 1 ms)



Smart Freezer Example

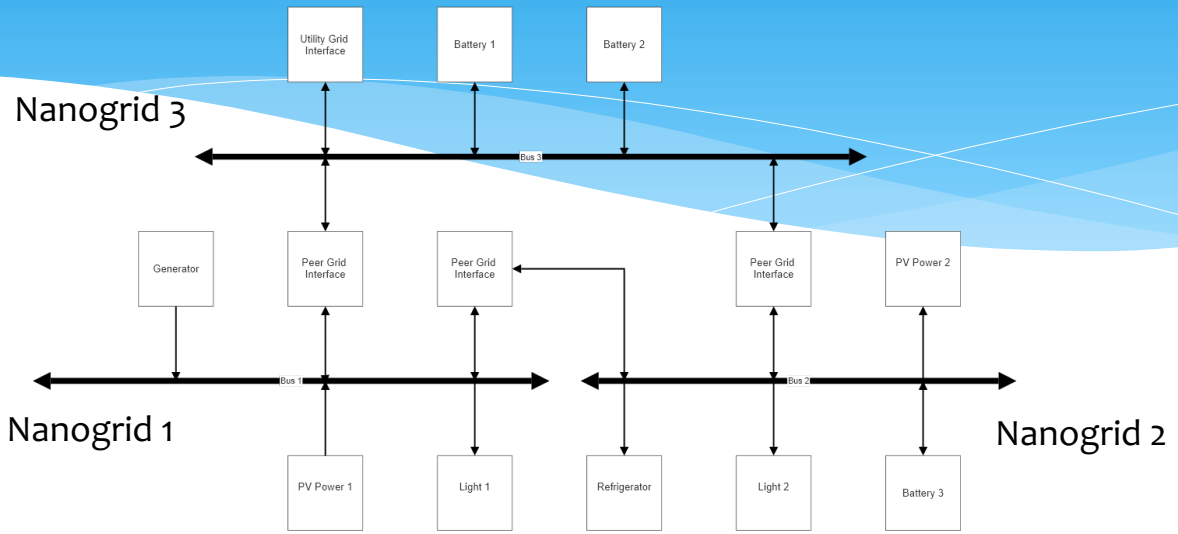
How and where are power and energy decisions made?



Power source availability and price vary over time.

Freezer can “store” energy by adjusting internal temperature.

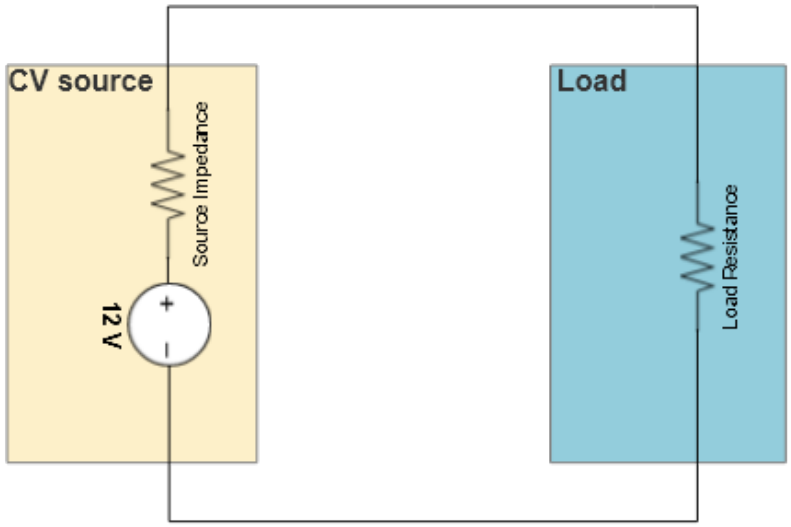
Power Management Functionality



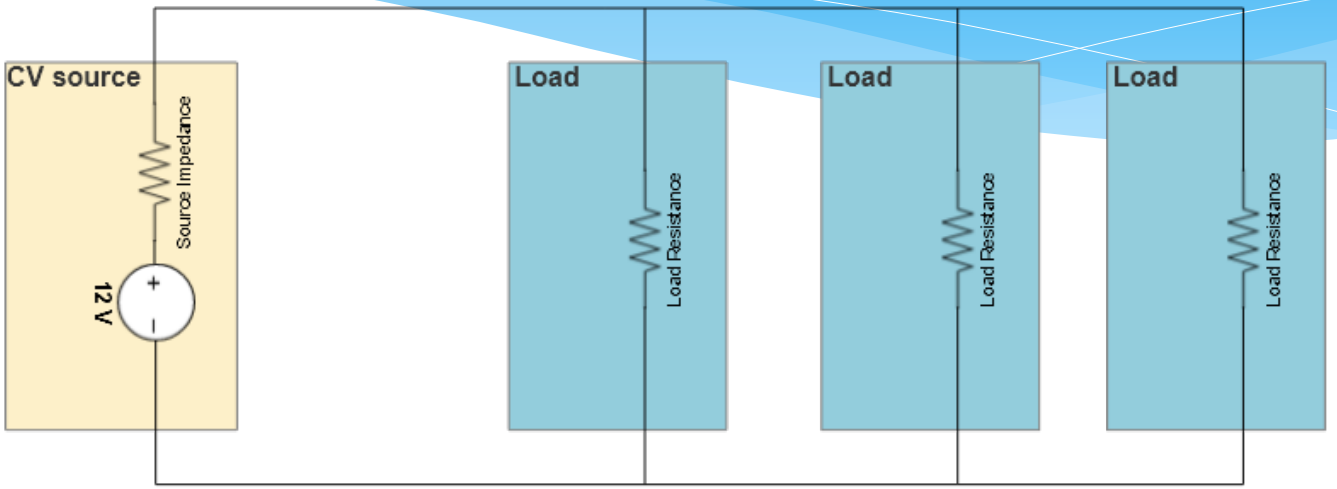
* Today: focus on functions rather than protocol details
  * What capabilities must ODG conforming devices implement?
  * What properties do they need to communicate?
  * Briefly discuss related issues like electrical, energy
* Today: focus on single nanogrids
  * Single domain for power allocation
  * All devices see approximately the same voltage

Minimal Microgrid

- Current limits
  - How to prevent overloads?
  - How to indicate overloads?
- Price limits
  - Real or imaginary?
  - How to indicate price overloads?
- Measurement & reporting
  - Where measured?
  - How reported?
- Device specific functions
  - Share communications with grid
  - PAYGO
  - Standards? OCF?

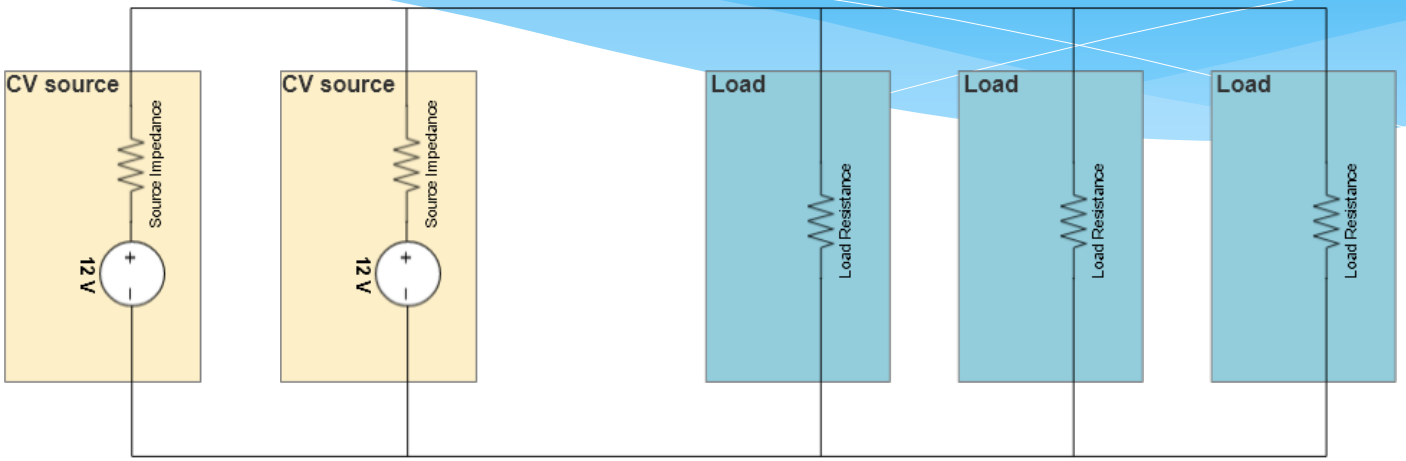


Multiple loads – priorities?



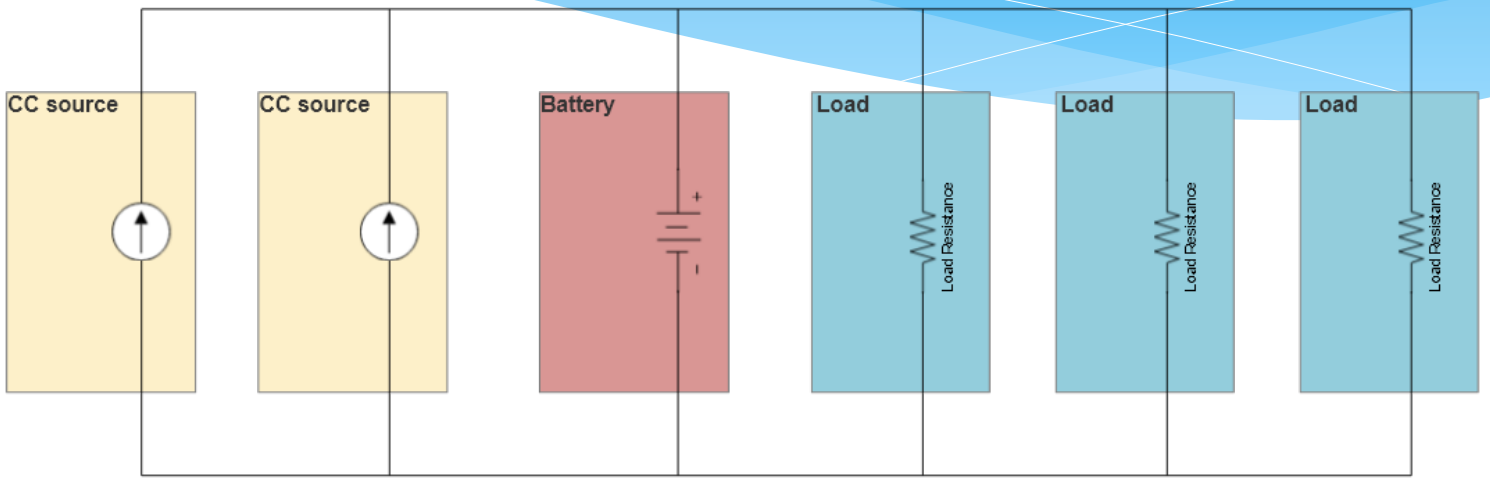
* How to manage overloads when load exceeds supply?
* Price is a useful proxy for priority
  * Source establishes a current price
  * Loads indicate what price they will accept

Multiple Sources – Source Priorities



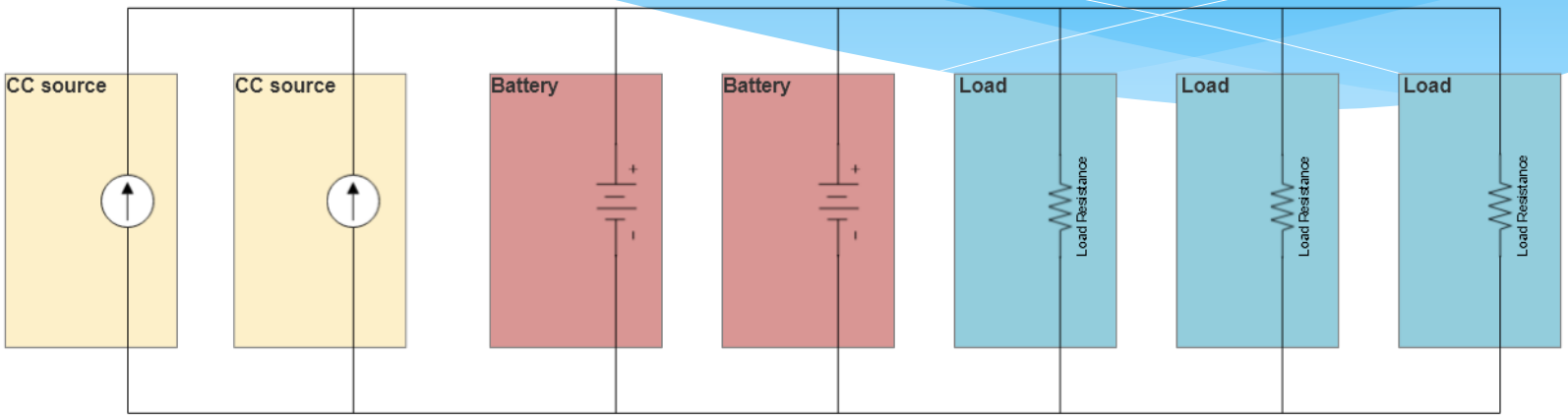
* How to allocate current between multiple sources?
  * Virtual impedance droop curves?
  * Must sources implement droop curves? If not then what?
  * Droop curves at 12V?
* How to establish a price?
  * Each source has its own price – linear combination?
  * Allocation by price versus allocation by capability?

Incorporating a Battery



* Source behavior needs to change as battery has low impedance
* Constant current vs. CV with setpoint?
  * How to choose the setpoint?
  * How to manage multiple sources?

Multiple Batteries



* Multiple identical batteries
  * Are they really identical? Aging? Mfg variation?
* Multiple batteries with varying types
  * Discuss the issues with parallel connections
  * Selective enable
  * Use of bus coupler

Protocol Issues – CoAP Example

* Confirmable versus non-confirmable messages
* Broadcast/multicast non-confirmable
* Device registration
* Security
* Proxies, firewalls, connected clouds

Load Control Variations

* LPD: GM server, load client
  * Load requests power only, GM responds with allocate
  * Server notifies of price changes? Broadcast?
  * How to arbitrate between identical loads?
* GM server, Load client
  * Load requests power & price, GM responds with allocate
  * GM notifies renegotiate? Broadcast? Includes new price?
* Load server, GM client
  * Load presents power and price as parameters
  * GM explicitly commands power level as set parameter
  * Load notifies GM of parameter changes

Related Standards / Industry Developments

* P2030.10
  * Second recirculation response submitted to IEEE
* LFEnergy
  * Microgrid SIG architecture focus on Hyphae
* Zephyr Developer Summit – June 8 – June 10
  * Mini-conference on Zephyr-driven power electronics planned
* OwnTech – Open Digital Power?
* P2030.10.1
  * Getting ready for ballot – no recent activity
* GOGLA Interop activities - ?
* OpenPAYGO Link - ?
* Angaza Nexus Channel / Nexus Channel Core - ?
* Open Connectivity Foundation / IoTivity - ?

Next Meeting / Feedback

* Next Meeting
  * 8 June 2021 – 1400 UTC
  * Zoom – Meeting ID 87518284403 password: opendcgrid
* Sharing Portals
  * Web site: https://open-dc-grid.org/
  * GitHub: https://github.com/open-dc-grid