

# Educational Demonstration of a City Microgrid

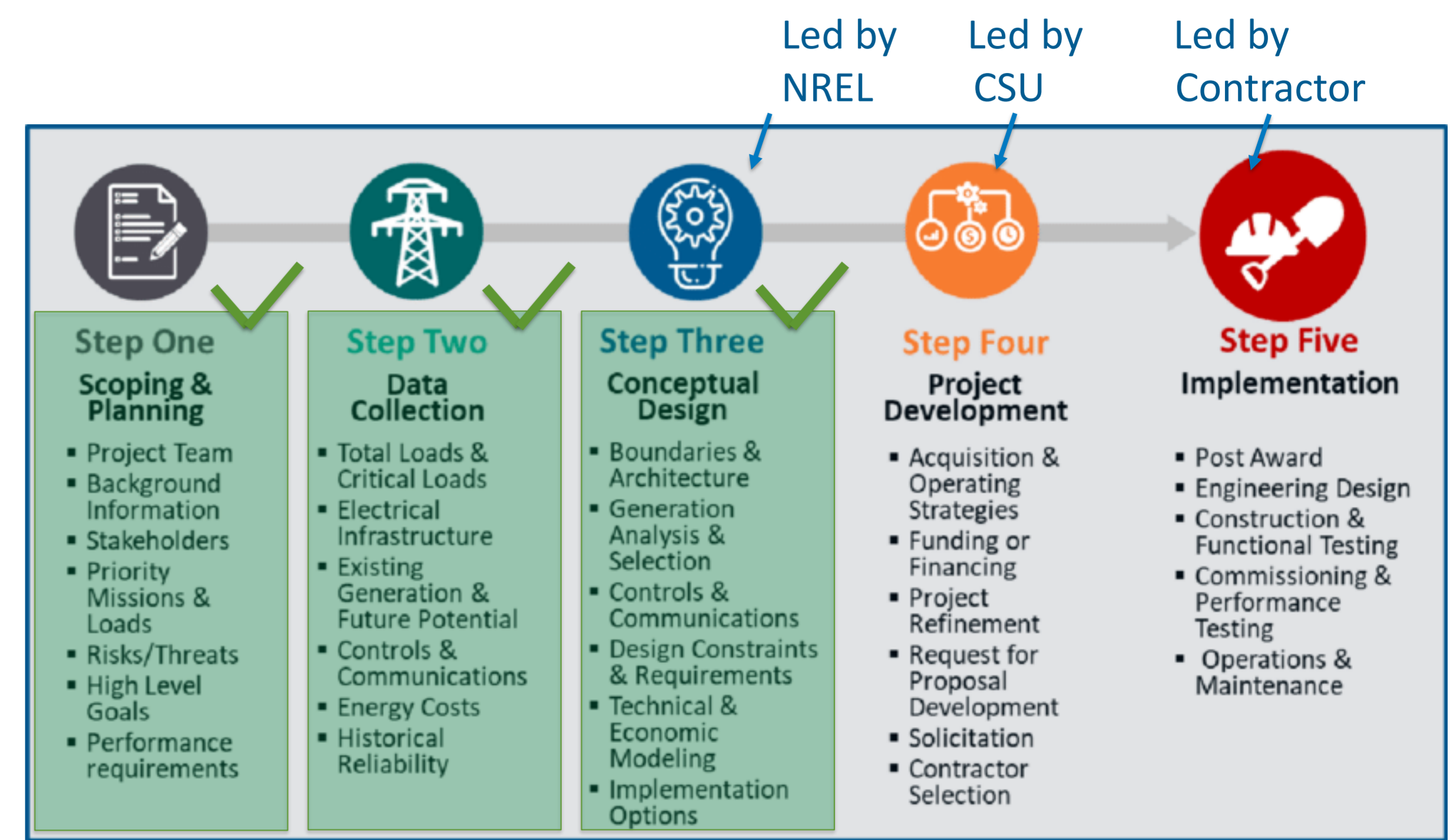
## OBJECTIVE

This microgrid is for education and for demonstrating technologies. It shows, in action with real hardware, how utility-scale solar plus storage can be used as the centerpiece of a microgrid and to generate values in multiple ways.

Image credit Colorado Springs Utilities (CSU)



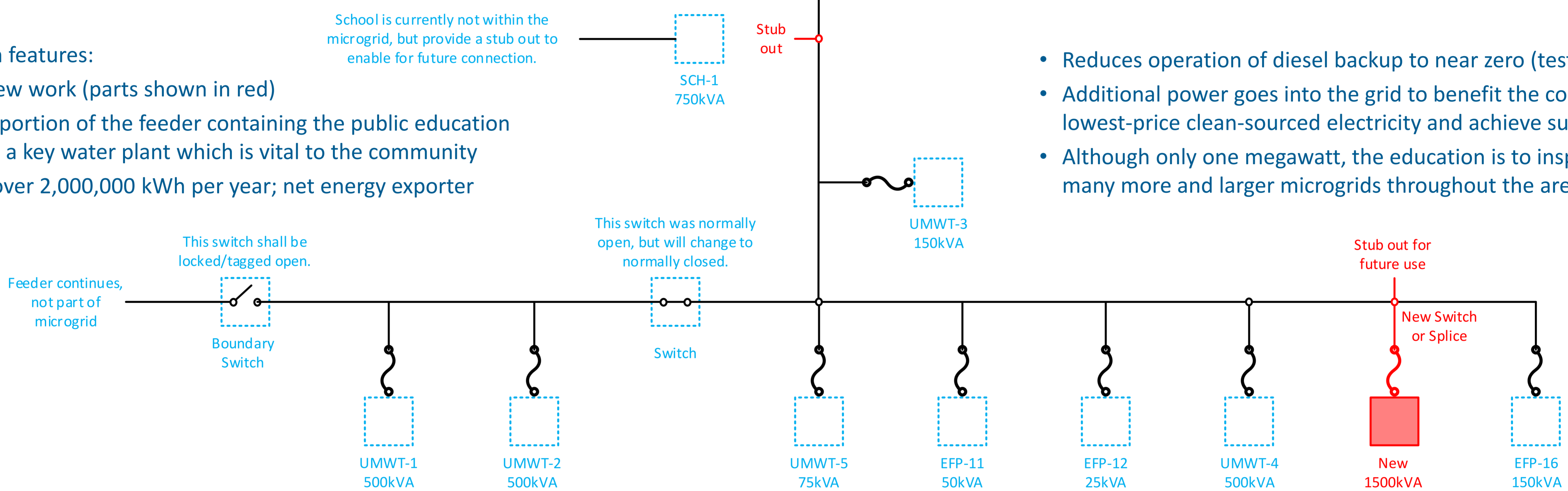
Part of the water treatment plant serving 80,000 people



City microgrid development status: steps 1-3 complete

### Power design features:

- Minimal new work (parts shown in red)
- Includes a portion of the feeder containing the public education center and a key water plant which is vital to the community
- Produces over 2,000,000 kWh per year; net energy exporter

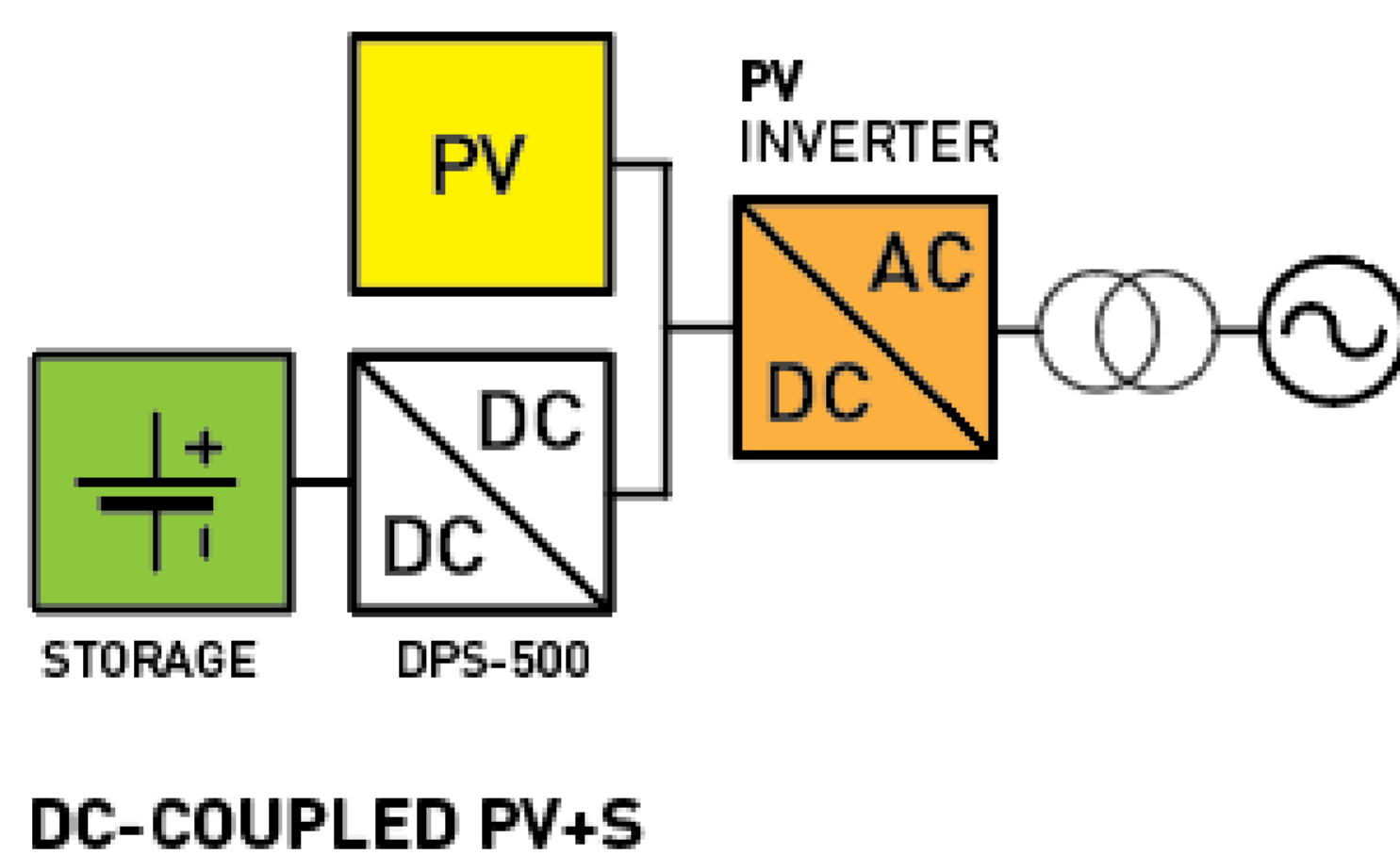


- Reduces operation of diesel backup to near zero (test runs only)
- Additional power goes into the grid to benefit the community with lowest-price clean-sourced electricity and achieve sustainability goals.
- Although only one megawatt, the education is to inspire building of many more and larger microgrids throughout the area for large impact.

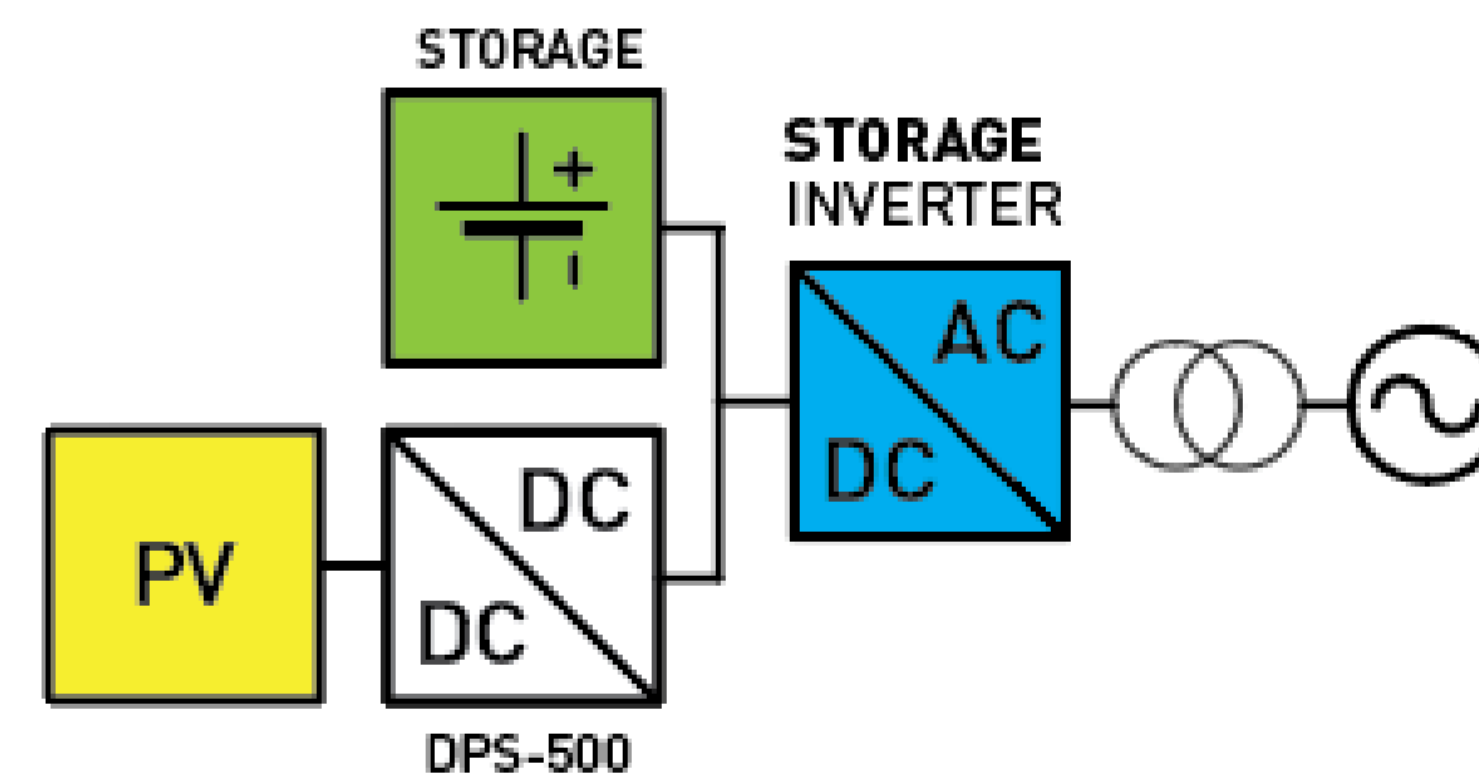
### Cyber design features:

- Controls for the microgrid are decentralized and automated to make operations very easy for CSU staff. In fact, the microgrid can operate itself based only on the market price signal.
- Future-casting of day-ahead hourly load versus solar generation to proactively dispatch the battery
- Some demonstrations are on an untrusted network to interact with utility via a secure air-gap as a deliberate demonstration of a mutually cybersecure interaction based on zero trust.

Image credit Dynapower <https://dynapower.com/ac-vs-dc-coupled-solar-plus-storage/>



DC-COUPLED PV+S



REVERSE DC-COUPLED PV+S

Comparison of DC-coupling types: only the storage inverter (blue) is grid forming

## Outcomes

Hybrid system has most AC-coupled and a smaller part (300kW) is reverse DC-coupled

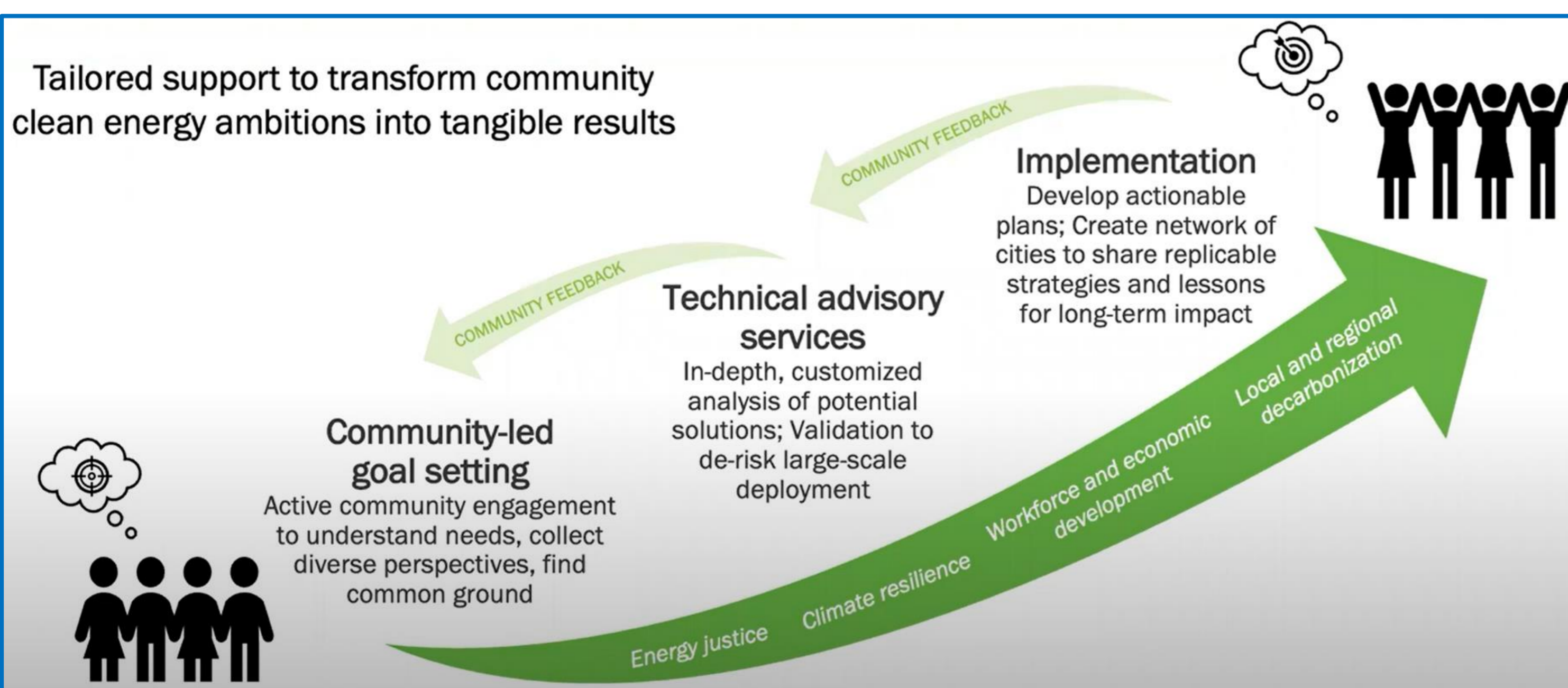
1.25 MW PV total

5.00 MWh BESS

12.47 kV, 3-phase recloser

## Why Reverse DC-Coupled Instead of AC?

In AC or regular DC coupled-systems, time-shifted PV energy gets converted three times. In reverse DC it is only converted twice.



<https://www.nrel.gov/state-local-tribal/c2c-in-depth-partnerships.html>



Image credit Colorado Springs Utilities (CSU)