Self Consumption in residential systems

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What is Self Consumption?

• A direct grid tie system is where solar energy produced, powers the house loads as limited self consumption, and excess solar production is exported back into the utility grid. This self consumption happens only while the loads are present at the same time as solar production. No energy is stored by the user for use at another time. Any power needed for loads, above what the solar is producing, is drawn from the utility.

• Self consumption, also known as Self-supply, is a system where some of the solar energy produced is stored on site for use at another time when solar production is less than the loads.

• Should it be called “Self-consumption” or “Self-supply”?
What is Self Consumption?

- The graph below demonstrates a typical load profile for a self consumption storage system.
- Peak net charging of batteries coincides with midday peak solar production and discharge is from 6:00-10:00 PM.
Why use Self Consumption?

- **Off grid**
  - The original solar self consumption
  - No utility grid available or connection very expensive
  - Often with generator backup
- **Net metering not available**
  - There is utility service, but utility interconnection and net-metering or feed-in are not available
- **Low feed-in tariff rates**
  - There is utility service, and interconnection is available, but feed-in tariff has low payback rates
- **Time of use rates, demand charges**
  - There is utility service, and interconnection is available, but electric rates are in a higher tier when drawing over a specific energy use level, or higher time of use rates at certain parts of the day.
Types of Self Consumption

- **Off grid**
  - No connection to the grid, or grid is only used for backup if the solar supply cannot keep up with the loads.

- **Self consumption with grid export**
  - Solar can recharge the battery during the day and when the battery is full and current loads are supplied, excess solar power can be exported to the grid. Energy from the battery can be used during peak use in the evening. Battery power can also be used to reduce demand charges at any time of the day.

- **Self consumption without grid export**
  - Solar can recharge the battery during the day and when the battery is full it will supply current loads, but not export to the grid. Energy from the battery can be used to supply the loads at any time the solar cannot do so. When the battery is depleted, the loads will be supplied by grid power until the sun comes up.
Types of Self Consumption systems

• Primary self consumption – Where the solar and battery can supply power to loads on the main house panel, but does not feed back to the utility.
  o The inverter is subject to grid tie anti-islanding limits.
  o The inverter will supply both the house and backup loads panels when there is grid power available.
  o If the inverter has the capability, it can also provide backup power during a utility outage.
  o A protected loads sub-panel is required for backup power in almost all cases.
  o The system will supply power to only the protected loads panel during a utility outage.

• Secondary self consumption – supplies only loads on a protected loads panel.
  o The inverter will supply the backup loads panel.
  o The inverter will supply the main house panel only when there is unlimited grid tie feed-in. Same as a grid tie inverter.
  o Supplies power to the protected loads panel during a utility outage.
Primary self consumption – without backup
Primary self consumption – with backup
Primary self consumption

Primary self consumption – AC coupled
Secondary self consumption – with backup
Sizing for self consumption

- **Storage**
  - Batteries are the most expensive component of the system. Minimize the size and cost for the best economics.
  - Most often sized to power the loads for one daily cycle at the appropriate depth of discharge.
  - May require detailed time of day use data. Hard to size for highly variable load profiles.
  - Extra capacity may be included for backup power.

- **Solar**
  - Most often sized to power the loads during the day and recharge the battery for the daily average. If net metering or even a reduced feed-in tariff is available, a larger solar array may be economical. A larger array will help production for cloudy days.
Inverters used for primary self consumption

• Inverters for primary self consumption
  o StorEdge 7.6kW uses a high voltage battery ie: 350 VDC to 450 VDC. Can be grid tied without storage. Can optionally supply backup power to a sub-panel with ~2 sec transfer time. Limited to 5kW output to backup system and requires an auto-transformer.
  o Fronius, SMA, OutBack SkyBox & others upcoming in the future. They will mostly use a high voltage battery. SkyBox will likely come in high voltage and 48 VDC versions.
  o Some third party integrators use metering on secondary type inverters to give them primary type capability.
  o Inverter integrated with the battery – Enphase, Tesla 2.0. The Enphase has no backup capability. These are AC coupled to the solar grid tie inverter.
Inverters used for secondary self consumption

- **Grid Zero and Peak Load Shaving**
  - Grid Zero and Peak Load Shaving modes will try to prevent grid usage by powering the loads with solar and/or battery until the battery is depleted. While the solar can supply some power the loads, it will offset the use of grid power. When the solar is not able to fully power the loads, the inverter will use the battery to power the loads until the battery is depleted. The next day the solar will recharge the battery. If the loads are too large for the inverter to power, it can draw on the grid to help power them. To make sure that the inverter does not push any power back to the grid it will always draw some small amount (~1 A 240 VAC) from the grid. This is complicated by measurements of Watts and VA and the power factor of the loads.
    - OutBack Power GS–A and FXR-A series inverters
    - Schneider XWPlus inverters
    - Sunny Island?
Inverters used for secondary self consumption

- **Offset and similar modes**
  - Offset, Grid Support, Enhanced AC Support or Load Support VDC modes work while there is still a connection to the grid. In these modes the inverter will use solar power to reduce the draw from the grid for loads on the protected loads panel. It will not offset loads on the main panel. The inverter can add grid and inverter power together to power larger loads. These modes will not use battery power for any loads unless there is a grid outage, and will keep the battery fully charged.
    - OutBack Power GS–A and FXR-A series inverters
    - Schneider XWPlus and SW inverters
    - Magnum MSH hybrid inverters
    - Sunny Island?
Inverters used for secondary self consumption

- **Drop Grid and similar modes**
  - Drop grid, Mini-grid, HBX, Online modes will disconnect the inverter from the grid and run the loads off grid using solar and battery power until the battery state of charge or voltage drops below a setpoint. At the low charge or voltage setpoint the inverter reconnects to the grid to power the loads and may charge the battery from the grid or not as it is setup to do. Loads are limited to the inverter capacity.
    - OutBack Power GS-A and FXR-A series inverters
    - Schneider XWPlus and SW inverters
    - Magnum MSH hybrid inverters (or external controls)
    - Samlex EVO inverters

- **AC coupling**
  - AC coupling does not work with any of these modes with these inverters. The possible exception is the older SMA setup, and that is no longer supported for grid tie systems with the newest US-40 Sunny Boy inverters.

- **Future inverters include the MidNite B-17**
  - Capabilities not specified yet
Batteries used for self consumption

- **Flooded lead acid**
  - High maintenance, high self discharge, low efficiency, hazardous gases and electrolyte. Low to medium high cycle life. Poor choice for grid tied standby backup systems.

- **Valve regulated lead acid - VRLA**
  - AGM or gel; sealed low maintenance, low self discharge, good efficiency, very low gassing. Low to medium high cycle life. Superior life in standby applications, up to 20 years.

- **Carbon enhanced lead acid**
  - Nano-carbon and Ultra lead acid; in VRLA configuration, low maintenance, low self discharge, higher efficiency, **good partial state of charge life**, and medium to high cycle life.
Batteries used for self consumption

• **Lithium-ION NMC**
  - Nickel Manganese Cobalt Oxide; very low maintenance, low self discharge, high efficiency, high cycle life, potentially hazardous in thermal runaway or in a fire. Available as UL listed high voltage systems. Moderately expensive but coming down in price due to extensive use in EV’s.

• **Lithium-ION LFP**
  - Lithium Iron Phosphate; very low maintenance, low self discharge, high efficiency, high cycle life, more stable, thermal runaway is less likely. Most expensive so far.

• **Aquion (aka: Saltwater)**
  - Aqueous Hybrid Ion; no maintenance, high self discharge, low rate charge and discharge, moderate efficiency, very high cycle life, completely non-toxic and non-hazardous, moderately expensive.
Batteries used for self consumption

• End of life ratings
  o Lead batteries capacity drops rapidly once they reach 80%, so that is considered their end of life point.
  o Lithium batteries will slowly have reduced capacity without any drop off point. End of life varies depending on the use, but 60% is commonly used by the manufacturers for stationary systems.
  o Aquion batteries drop faster after 70% capacity is reached and that is considered their end of life.

• Temperature ratings
  o Lead batteries can freeze if fully discharged, but will withstand -40° if fully charged. The capacity drops off dramatically at lower temperatures and life is severely shortened by operation at higher temperatures.
  o Lithium battery capacity will not be affected by temperature as much as lead or other batteries. However, their operating range can be limited to as wide as -4°F to 122°F or as narrow as 14°F to 113°F.
  o Aquion batteries will operate down to 14°F with somewhat reduced capacity. They will operate at up to a daily average of 104°F without shortened life.

• Outdoor ratings
  o Lead and Aquion need enclosures. Lithium is often rated for outdoors, and this may be required by code soon.
Thank you!

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