Definitions, Standards and Test Procedures for Grid Services from Devices

GRID MODERNIZATION INITIATIVE U.S. Department of Energy

Project Description

Develop characterization test protocol and model-based performance metrics as a *Recommended Practice* for devices' (DERs') ability to provide a broad range of grid services, i.e., to provide the flexibility required to operate a clean, reliable power grid at reasonable cost.

Devices (DERs)

Responsive, flexible loads
- Water heaters
- Refrigerators
- Air conditioners
- Commercial rooftop units
- Commercial refrigeration
- Commercial lighting
- Electric vehicles (charging only)
- Electrolyzers

Storage
- Battery / inverters
- Thermal energy storage
- Electric vehicles (charging & discharging)

Distributed generation
- PV solar / inverters
- Fuel cells

Grid Services
- Peak load management (capacity)
- Energy market price response (wholesale energy cost)
- Capacity market dispatch (market value)
- Frequency regulation (market value)
- Spinning reserve (market value)
- Ramping (new)
- Artificial inertia (new)
- Distribution voltage management (new)

Objectives/Deliverables
- **Simple, low-cost testing protocols** manufacturers can use to characterize equipment performance
- **General, standard device model reflecting test results** for each device class
- **Proven means of estimating performance metrics** for a **standard set of grid services** from the test results
- **Protocol that can be regionalized** to reflect local markets, new services, weather, loads, etc.
- **Generic DER device flexibility model** based on battery equivalent

Impacts/Outcomes
- *Reward innovation,* help manufacturers understand opportunities, enlarge the market for devices
- *Validated performance & value for grid operator decisions* on purchases, programs, subsidies, rebates, markets, planning, operations
- *Independently validated information for consumers & 3rd parties* for purchase decisions
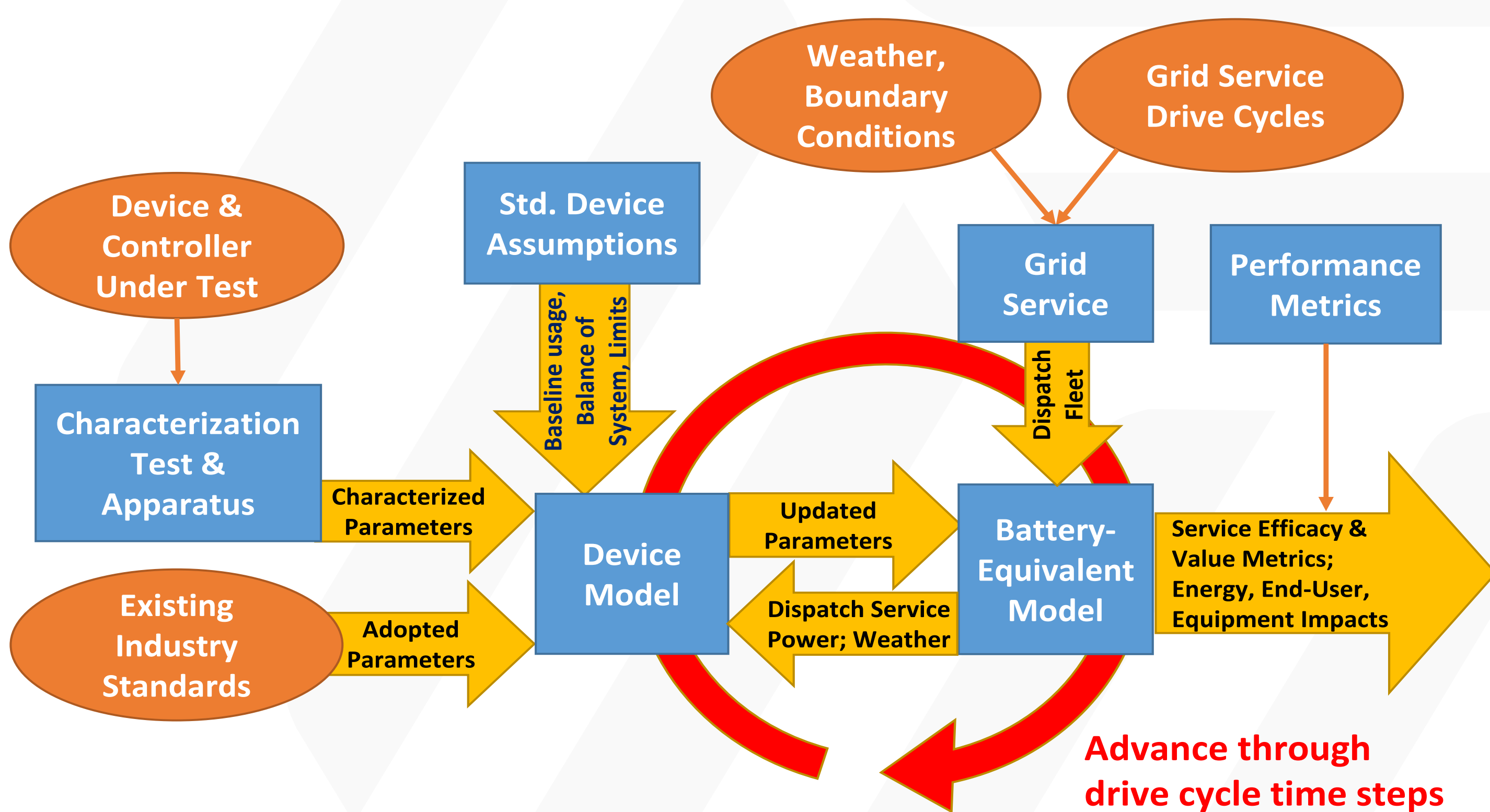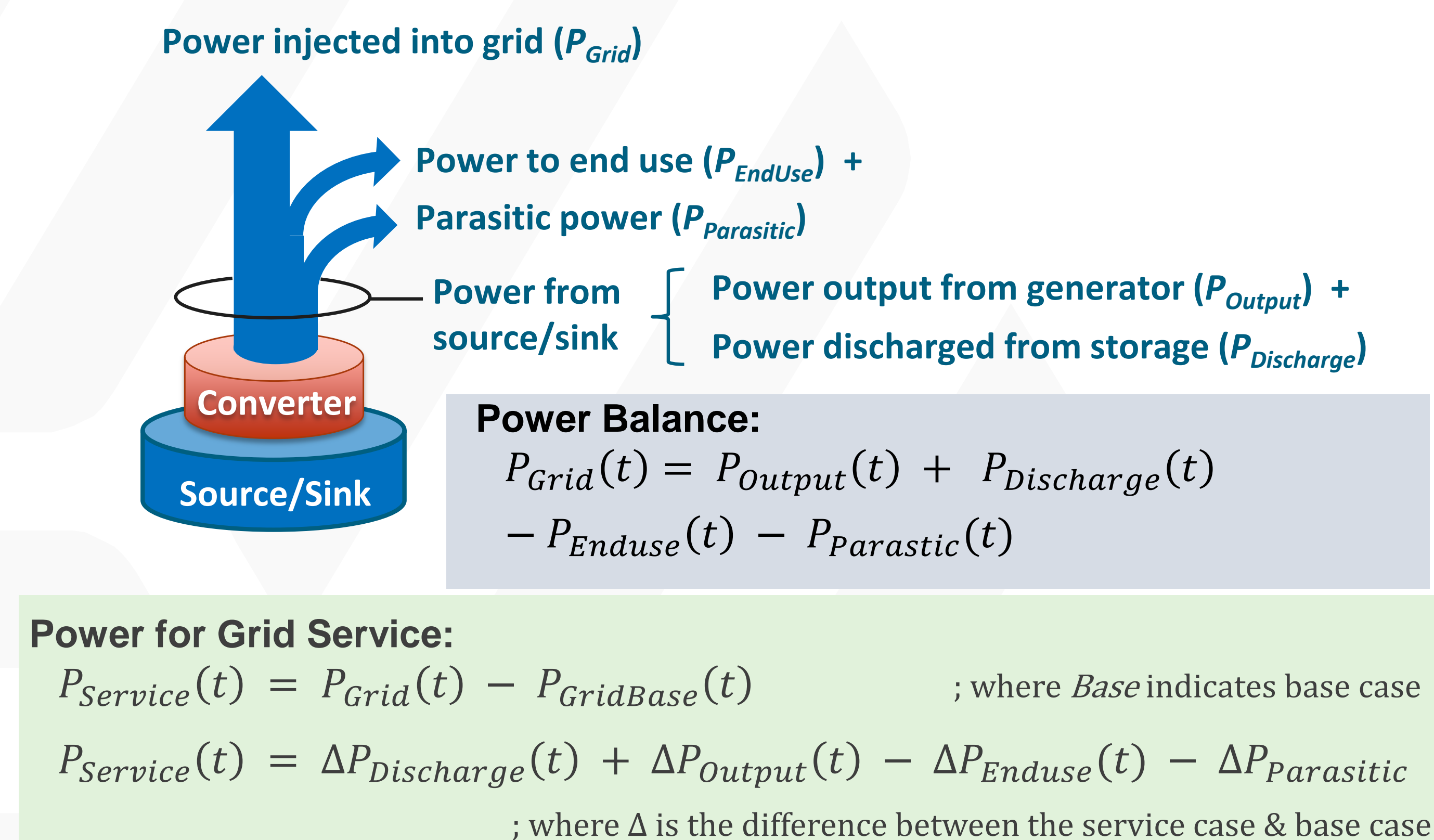- "Battery Equivalent+" model can provide "plug-and-play" for device models in planning & operation tools

Figure 1. Device Characterization Process

Power injected into grid (P_{Grid})

Power to end use (P_{EndUse}) + Parasitic power ($P_{Parasitic}$)

Power from source/sink { Power output from generator (P_{Output}) + Power discharged from storage ($P_{Discharge}$)

Power Balance:
$$P_{Grid}(t) = P_{Output}(t) + P_{Discharge}(t) - P_{Enduse}(t) - P_{Parasitic}(t)$$

Power for Grid Service:
$$P_{Service}(t) = P_{Grid}(t) - P_{GridBase}(t) \quad ; \text{where } Base \text{ indicates base case}$$
$$P_{Service}(t) = \Delta P_{Discharge}(t) + \Delta P_{Output}(t) - \Delta P_{Enduse}(t) - \Delta P_{Parasitic}$$
; where Δ is the difference between the service case & base case

Figure 2. Generic Battery Equivalent+ Device Model

Significant Milestones (FY16-FY18)	Status	Due Date
1. **Standard definitions & drive cycles for grid services** (draft for industry review)	1. Complete ✓	October 1, 2016
2. **General device model** (draft for industry review)	2. Complete ✓	
3. **Extrapolation procedure for performance of grid services**	3. Complete ✓	April 1, 2017
4. Draft *Recommended Practice* (vetted with industry)	4. Underway (WORK IN PROGRESS)	October 1, 2017
5. **Trials of device characterization protocols** (each device class)		April 1, 2018
6. **Manufacturers review characterization protocol & test results**		
7. **Proof-of-concept testing validates extrapolation procedure**		October 1, 2018
8. **Stakeholder group consensus that *Recommended Practice* is useful & accurate**		April 1, 2019

Progress to Date
- **Developed definitions & drive cycles for broad range of grid services**
- **Developed generic device model (battery equivalent+) & extrapolation framework**
- **Published framework (Recommend Practice Chs. 1 & 2) for industry review (3/17)**
- **Organized series of webinars & briefings leading up to 2nd Industry Workshop:**
  - GridWise Alliance webinar (n = 35*)
  - Thermal energy storage briefings (n = 2*)
  - Electric vehicle meeting briefing (n = 13*)
  - PV/batteries/inverters (n= 321*)
  - Commercial lighting (n = 27*)
  - HVAC & appliances (n=21*)
- **Partnered with the GridWise Alliance to host 2nd Industry workshop with sponsors GE & Intel @ GE's GridIQ Center in Atlanta GA March 21-22, 2017 (n = 36*)**

* Counts exclude DOE and national laboratory participants