Terminology and Definitions

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Terminology and Definitions

- DOE envisions a future where **Smart** and **Grid-Connected** **Devices** provide value through engagement with **End-User** and **Grid Services**. Quantifying device **Actions** through **Physical Characterization** is a key step toward this future.

- **These terms** need to be defined in order clarify this vision and to provide common ground for discussion.

- **How can these terms be better defined?**
- **What other terms are important to define?**

Terminology and Definitions

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Devices

- **"Devices"** include all appliances, equipment, or systems located in residential, commercial, or industrial settings. "Devices" are equivalent to "Building End-Use Equipment and Appliances".

- The list of devices is very long. Some examples include:

  - Refrigerator   - Roof top unit (RTU)   - Computer/printer
  - Pool pump   - Inverter   - Induction furnace
  - Television   - Vehicle charger   - Storage

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Smart Device

- **"Smart Devices"** modify their state by employing **decision logic** that is informed by:
  - Customer requirements
  - External input signals
  - Self-awareness
  - Interactions with external devices or systems

- Example of a smart refrigerator and RTU:
  - Incoming signal requests 500W load increase from 5:00-5:30am
  - Refrigerator is scheduled for a 30 min defrost cycle at 4:00am
  - Refrigerator/HVAC/EMS negotiate the following agreement:
    - Refrigerator delays defrost cycle until 4:45-5:15am
    - RTU pre-heats building from 5:15-5:30am

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Connected Device

- **"Connected Devices" receive** and **act** on **signals** generated by utilities, third parties, energy management systems, or other devices.

- Example of connected devices:
  - HVAC senses clogged filter and transmits maintenance request to 3rd party. Refrigerator and clothes dryer detect HVAC signal and inform owner that the water filter and exhaust duct are due for service within the next two weeks.

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Services

- **"Services"** are resources or functions provided for the benefit of interested parties.

- **"Grid Services"**
  - Energy related products and services purchased, or incentivized, by the power grid to improve grid operations.
  - Examples: Peak shifting, ancillary functions, renewable capacity firming

- **"End-User Services"**
  - Energy related products and services purchased by consumers to optimize their overall energy costs, comfort, or convenience.
  - Examples: Maintenance, diagnostics, automated commissioning

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Device Actions

- **"Device Actions"** include the modification of operating state, generation of information, or interaction with other devices for the benefit of customers, utilities, or third parties.

- Example device actions include:
  - Modifying electrical load
  - Scheduling future events
  - Reporting maintenance issues
  - Identifying cost saving opportunities

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Physical Characterization

- **"Physical Characterization"** involves quantifying the operating conditions, actions, or impacts that are possible for a device.

- Physical characterization is not energy efficiency testing (e.g. appliance standards testing).

- Examples of physical characterization include changes in…
  - Energy consumption
  - Power
  - Time
  - Frequency
  - Temperature
  - Service life

Terminology and Definitions

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Public Comments

DOE envisions a future where **Smart** and **Grid-Connected Devices** provide value through engagement with **End-User** and **Grid Services**. Quantifying device **Actions** through **Physical Characterization** is a key step toward this future.

- **How can these terms be better defined?**

- **What other terms are important to define?**

Terminology and Definitions

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End-User and Grid Services

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End-User and Grid Services

- Physical characterization of smart and connected devices is needed to access valuable services.

- Example service categories include:
  - Grid services
  - End-User services
  - Other?

- **What other service categories are important to consider?**

End-User and Grid Services

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Grid Services

- Grid Services: Energy or energy-related products and services purchased, or incentivized, by the power grid to improve grid operations, reduce cost, or improve reliability.

- Example grid services include:

  - Capacity
  - Cold start
  - Peak shifting
  - Congestion
  - Load following

  - Ancillary
  - Direct load control
  - Scheduling imbalance
  - Renewable capacity firming
  - etc…

- **What other grid-related services are on the horizon?**

- **Does a clean-energy economy require new services?**

End-User and Grid Services

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End-User Services

- End-User Services: Energy and energy-related products and services purchased by customer or building owner to reduce energy consumption or cost, improve comfort, or enhance operations.

- Example end-user services include:
  – Operation and maintenance
  – Device diagnostics
  – Automated commissioning
  – Purchase energy from third-party distributed energy provider

- **What other end-user services are on the horizon?**

End-User and Grid Services

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Public Comments

We recognize that identification of services that can be delivered by smart and connected devices is challenging. We are seeking input on this topic.

- **What other service categories are important to consider (e.g. grid, end-user, other)?**

- **What other grid-related and end-user services are on the horizon?**

End-User and Grid Services

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Physical Characterization Framework

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Physical Characterization Framework

- **Physical Characterization** of smart and connected devices is needed to access valuable services.

- DOE is seeking to develop a **Framework** for characterizing smart and connected devices.

- We envision that this framework would...
  - Define a systematic approach to characterizing devices
  - Describe protocols for characterizing device actions

- **What should a physical characterization framework contain?**
- **What device actions should be characterized?**

Physical Characterization Framework

What is Physical Characterization?

Illustrative

- Physical characterization is…

  – The evaluation of device actions and performance

  – Can it be externally controlled? If so, how?

  – To what extent? How long?

  – What are consumer impacts?

- Physical characterization is not…

  – Annual energy efficiency testing

  – Seasonally adjusted rating

  – Label development program

  – Test procedure development

  – ENERGY STAR

Characterization is the first step toward:
- Mapping physical characterization to services that can be delivered
- Identifying value to consumer and operational benefits
- Evaluating national impact of smart and connected devices

Physical Characterization Framework

Framework Content

- A physical characterization framework would provide a systematic approach for evaluating the performance of smart and connected devices.

- Example content for a framework may include:
  - Conceptual model
  - Reference implementations
  - Device test protocols
  - Metrics for comparison
  - Other?

- **What content should the framework contain?**

Physical Characterization Framework

Device Actions

- A key component of the framework will likely include which, and how, device actions are characterized.

- Example device actions to be characterized may include:
  - Magnitude of load modification   (thermostat adjustment, delay tasks)
  - Time dependent behavior   (in-rush current, lock-outs, delays)
  - Impacts on consumption   (consumption variation)
  - Information generated   (measured confirmation, forecast)
  - Operational limits   (duration, frequency, deficit)

- **What device actions should be characterized?**

Physical Characterization Framework

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Public Comments

We recognize that development of a physical characterization framework is challenging and are seeking input on this topic.

- **What should a physical characterization framework contain?**

- **What device actions should be characterized?**

Physical Characterization Framework

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Device Testing at ESIF

- The DOE, PNNL and NREL are launching research at ESIF to characterize the performance of smart and connected devices.

- Initial testing will be used to inform development, and provide validation, of the physical characterization framework.

- NREL facilities leverage existing infrastructure and experience.
  - Device testing capabilities include appliances, HVAC, energy management systems, generation, and energy storage.
  - Testing can occur at the device or integrated system levels.

Physical Characterization Framework

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Value, Benefits & Metrics

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Value, Benefits & Metrics

- DOE envisions that considerable **<u>Value & Benefits</u>** can be derived from deployment of smart and connected devices at scale.

- Recent analyses suggest that significant value exists for services enabled by smart and connected devices.
    - McKinsey (2010)   ≈ $30B/yr   (grid and customer applications)
    - PNNL (2013)   ≈ $22B/yr   (grid services only)

- **What studies are there that estimate the value and benefits of smart and connected devices? From the grid perspective? From the consumer perspective?**

Value, Benefits & Metrics

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National Benefits

- Metrics are required to quantify the national value and benefits of smart and connected devices.

- Example national benefit metrics may include:
  - Total value   ($)
  - Societal benefit   (CO_2)
  - Consumer acceptance   (# Devices)

- **What metrics should be considered at the national level?**

Value, Benefits & Metrics

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Device Metrics

- Device level metrics are needed to quantify benefits at three primary levels:
  - Consumer, Utility, and National levels

- Example device level metrics include:
  - Fraction or multiple of baseline consumption (e.g. load)
  - Fraction or multiple of baseline service (e.g. temperature)
  - Time, Binary Y/N, # of attributes, information

- Physical characterization of individual devices is required in order to project the performance of a population of devices.

- **What metrics should be considered at the device level?**

Value, Benefits & Metrics

Public Comments

We understand that quantifying the value and benefits of smart and connected devices is challenging. We are seeking input on this topic.

- **What are the national level values and benefits?**

- **What studies are there that estimate the value and benefits of smart and connected devices? From the grid-perspective? From the consumer perspective?**

- **What metrics should be considered? At the national level? At the device level?**

Value, Benefits & Metrics

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