# Battery Energy storage systems (BESS): ancillary services and beyond

**Sep 6th, 2018**

# GE Energy Consulting: Systems engineers solving challenges that deliver customer value

- **Power economics**
  - ✓ Power systems strategy
  - ✓ Energy financial analytics

Example: GE Energy Consulting conducts the first-ever nationwide analysis of wind energy integration in Canada to reduce greenhouse gas emissions and generate new export opportunities.

- **Power systems operations & planning**
  - ✓ Transmission and distribution studies
  - ✓ Equipment applications

Example: GE Energy Consulting conducted technical and economic studies to assess the feasibility of a microgrid solution for Clarkson University and SUNY Potsdam.

- **Global power projects**
  - ✓ Thermal generation
  - ✓ Renewables, controls & protection

Example: GE Energy Consulting engineers configured and installed blocking filter technology to reduce system disruptions from the grid to a mining customer.

# Trends disrupting the power sector from generation to transmission and distribution

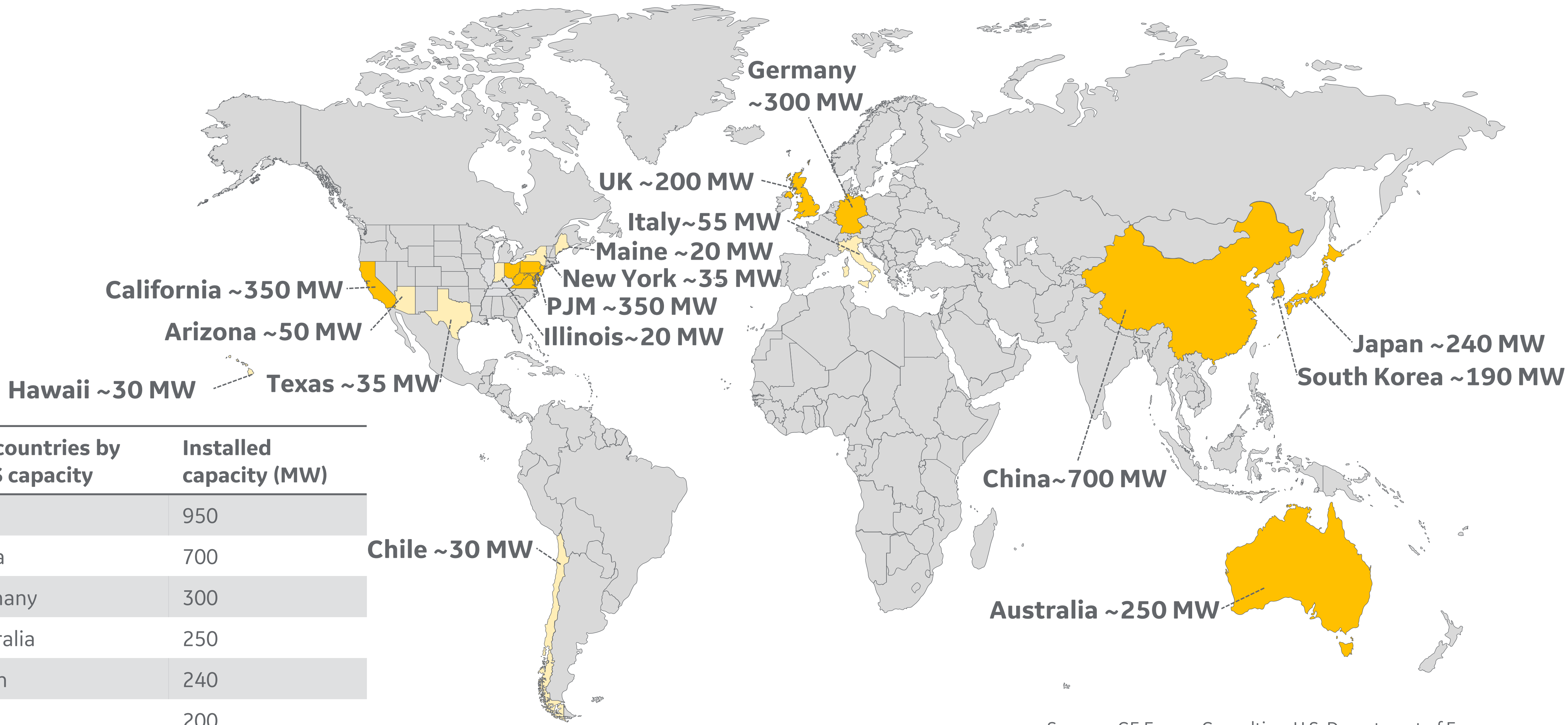
- **Decarbonization – by 2040, RENEWABLES will represent 30% of global net electricity ... or more?**
  - Generation is becoming difficult to forecast & variable
  - Grid stability, Congestion Volatility on electricity system

- **Decentralization - growing penetration of distributed resources**
  - End user becomes an active actor of the power system ('pro-sumer')
  - Growing complexity of distribution grids

- **Electrification - electrification of energy uses, transport (EVs) and heating**
  - Growth of Electricity demand, and an acceleration of decentralization of the power sector

- **Digitization - growing the number of connected devices & smart sensors**
  - Allowing decision making based on dynamic and nodal prices

# The installed power capacity of grid BESS is around 2.5 GW globally (with energy capacity roughly twice that)




| Top countries by BESS capacity | Installed capacity (MW) |
|---|---|
| USA | 950 |
| China | 700 |
| Germany | 300 |
| Australia | 250 |
| Japan | 240 |
| UK | 200 |

Sources: GE Energy Consulting, U.S. Department of Energy

# The usage of BESS storage in power systems has grown rapidly, but value stacks for selected applications only

**Valued in several regions**

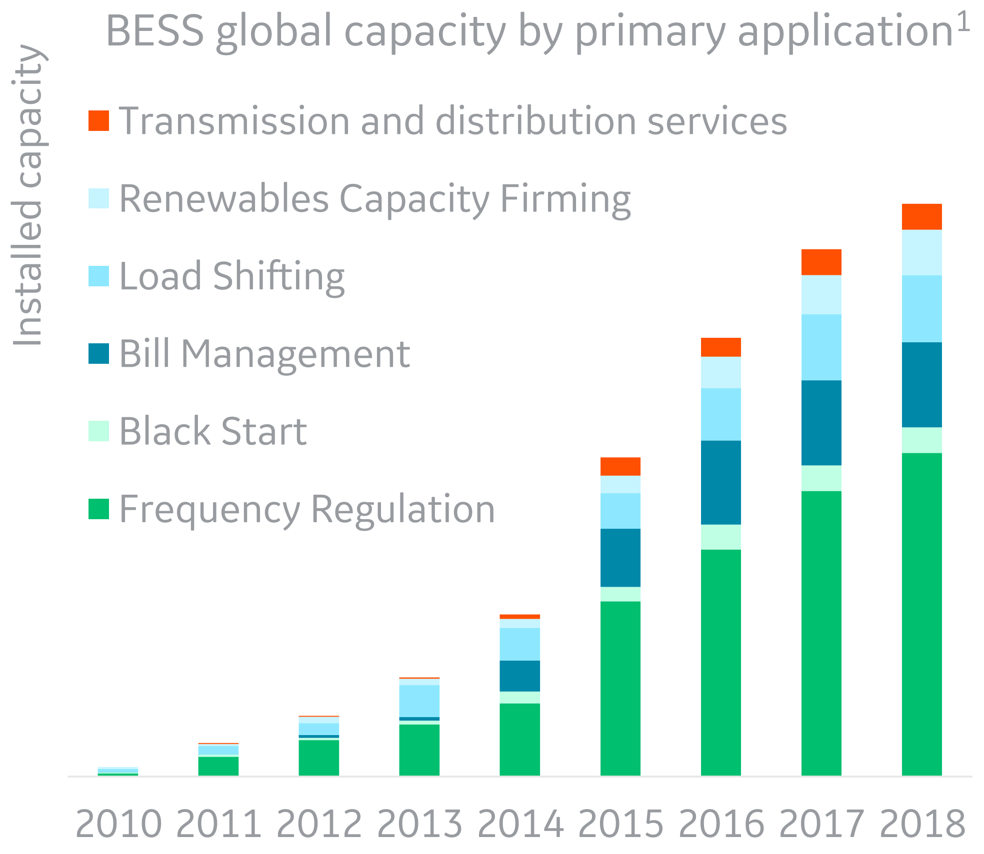
**Ancillary services**
- Frequency regulation (and balancing)
- Voltage support
- Black start

**Early adoption**

**Energy and capacity services**
- Load shifting
- Bill management
- Renewable capacity firming

**Individual small-scale projects**

**Transmission and distribution services**
- Transmission/distribution upgrade deferral
- Grid Reliability
- Microgrid capability



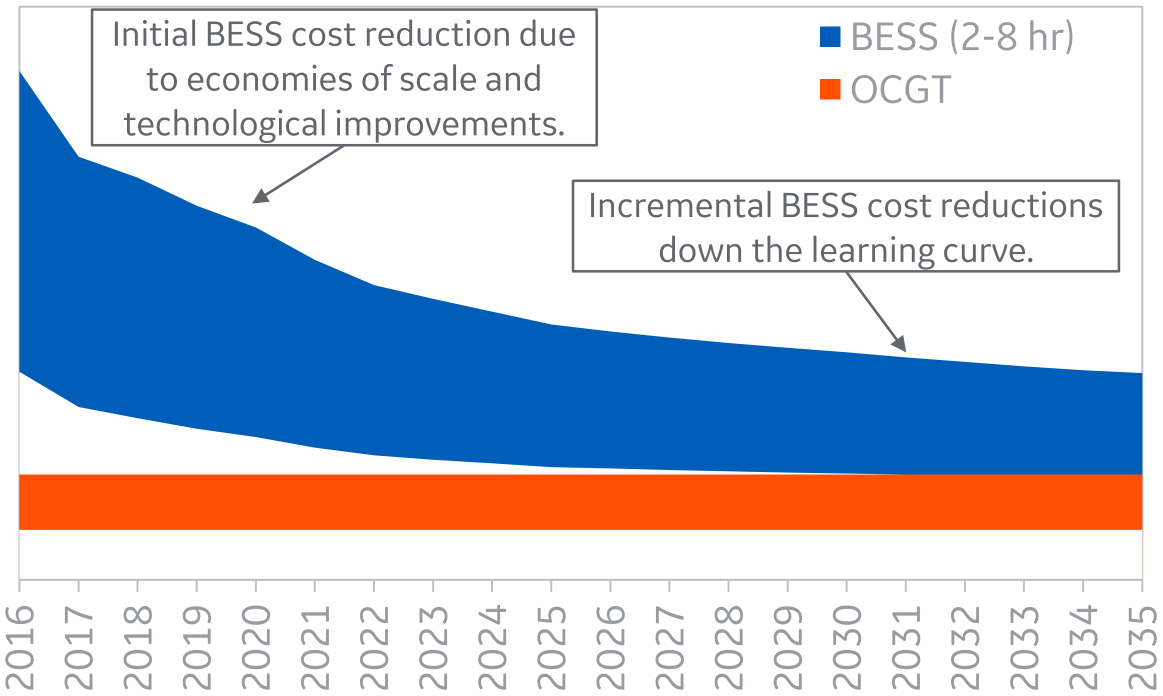

[1]Many of the batteries provide several services in parallel to maximize benefits to the system, e.g. load shifting and frequency regulation. Source: U.S. Department of Energy

# On economical basis, BESS are likely to provide capacity only in combination with ancillary services in near term

**While Load shifting or peaking capacity is the largest potential opportunity for BESS over the long term, BESS applications in ancillary segment will dominate in near term:**

- BESS needs to have lower costs than conventional peaking capacity to enter energy segment.
- Despite recent reduction in battery costs, BESS is not expected to be competitive with OCGT on annualized fixed cost basis in near term.
- However, BESS has faster response times and can start up quicker than OCGT, meaning that BESS have an advantage in high-value ancillary segment.
- Also, environmental consideration and the benefits of smaller distributed generation resources is another driving force behind the integration of BESS into energy segment.

**Annual levelized fixed cost forecast[1]**

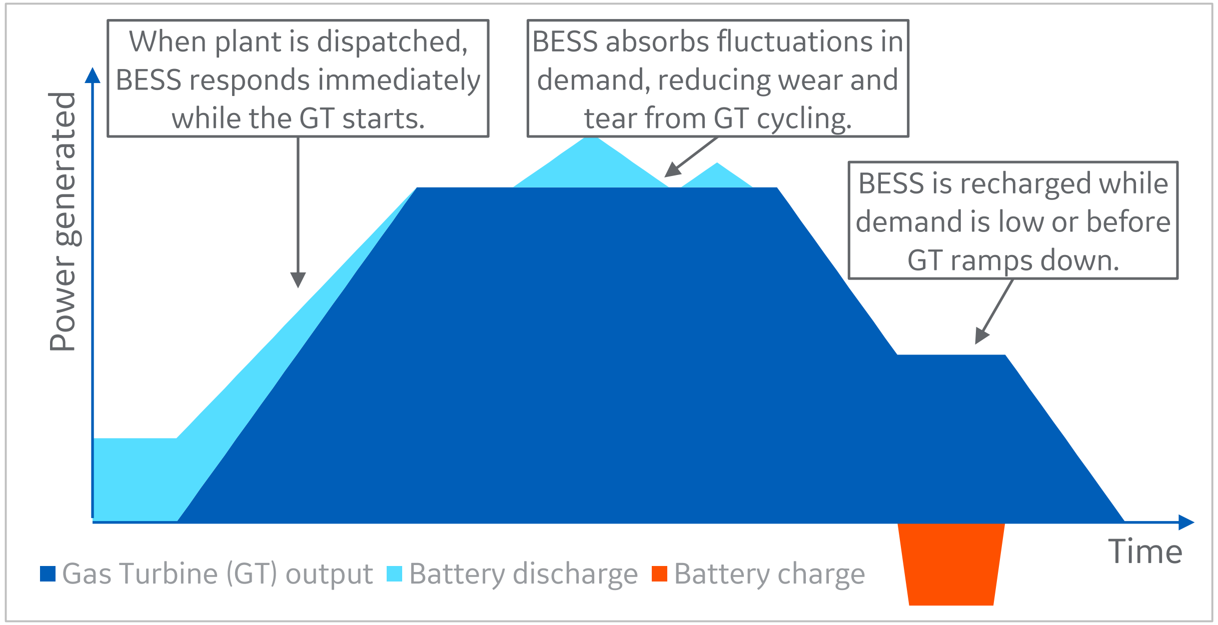



[1]Costs include construction and fixed O&M. Assumed economical lifetime is 20 years with full battery module replacement after 10 years.
Required return on investment – 7.5%.
Source: GE Energy consulting, IHS Markit (BESS cost forecast).

# Hybrid power plant combines the instantaneous response of BESS with the extended duration of a GT

**GE and Southern California Edison recently completed two hybrid power plants that each combined a 50 MW gas combustion turbine with a 10 MW / 4.3 MWh Li-ion BESS:**

- Hybridisation allows for greater flexibility and additional revenue streams for peaker power plants. The most significant of which is the ability to collect payments against full GT capacity.
- Additional services available through the hybridisation are black start and voltage support.
- While the goal of GE and Southern California Edison project was to quell concerns around changing regulations and grid requirements following California's Aliso Canyon energy emergency, hybridisation could be a promising application for BESS.




**Key services that can be economically provided:**

| | GT | BESS | Hybrid |
|---|---|---|---|
| Energy | X | | X |
| Spinning reserve | | X | X |
| Non-spinning reserve | X | | X |
| Voltage support | | X | X |

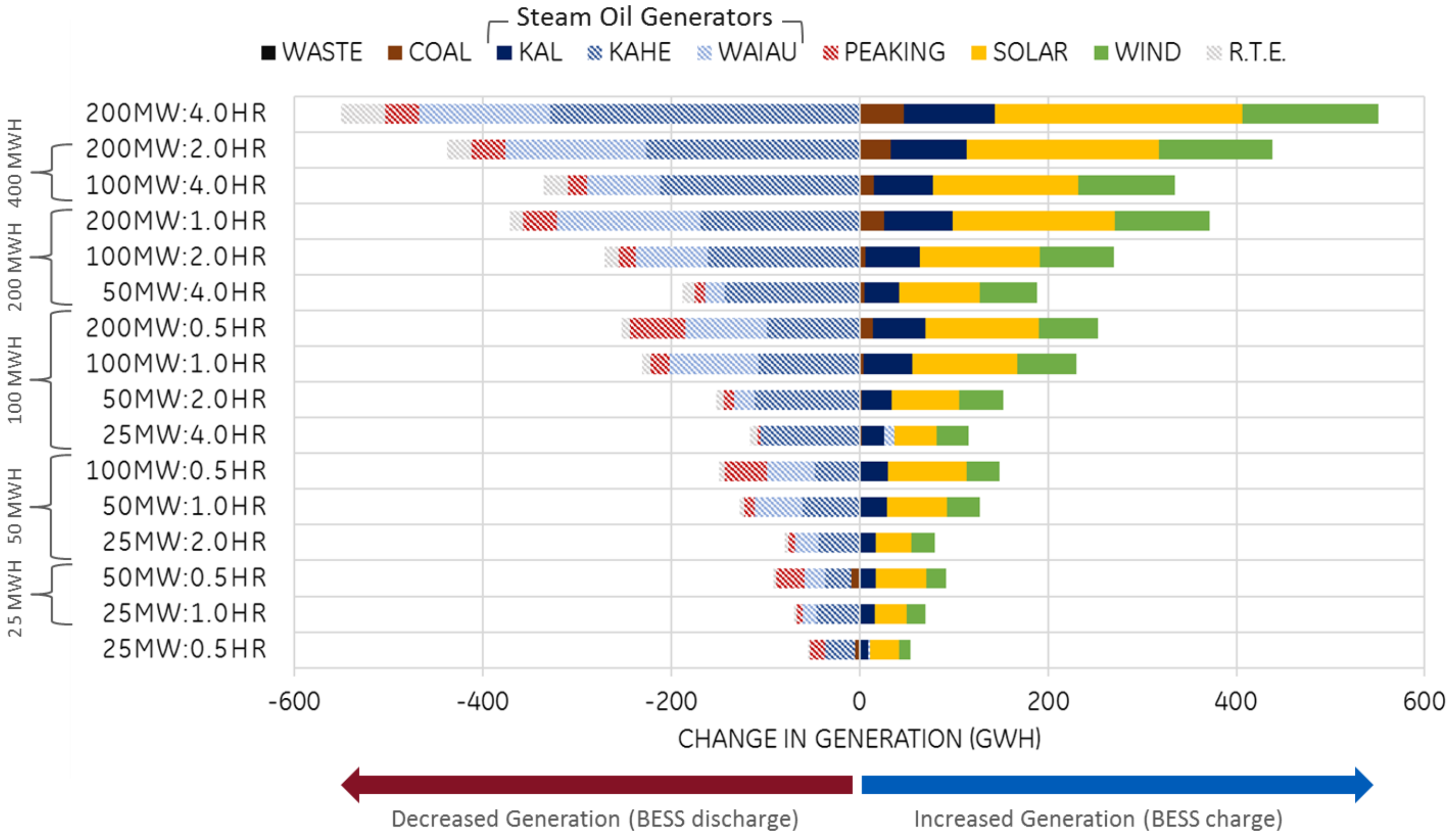
# An example from Hawaii: BESS increases generation from renewables through provision of ancillary services

**BESS reduces renewable curtailment :**

- through **load shifting**, i.e. charging during hours of surplus wind and solar energy and discharging during peak load;
- through **reserve provision**, i.e. allowing conventional generators to turn offline and "free up" space on the grid for variable renewables

While both of these services are valuable to the power system on Oahu, Hawaii, **reserve provision has higher impact in this system**.

**Conclusion:** Reserve assets can be valuable tools to reduce curtailment before there is an economical case for higher cost long-duration BESS to shift load.




Source: https://www.hnei.hawaii.edu/projects/oahu-distributed-pv-grid-stability-study

# The combination of financial incentives, legislative barriers removal and smart system planning is key for BESS uptake

| Key barriers to wider BESS adoption: | There are three key strategies each aimed at solving one of the barriers for BESS adoption, being deployed by several developed power systems: |
|---|---|
| High investment cost requirement | • **financial incentives**<br>Financial incentives, including rebates, tax credits, and grants, are available in several states in the ***USA***. A grant of up to 25% plus a low interest loan scheme for residential storage is available in ***Germany***. ***UK*** allocated £50 million for storage and DSR innovation. |
| Industry rules made for traditional generation | • **storage procurement policies**<br>FERC Order 841 removed barriers to the participation of electric storage resources in power systems in the ***USA***, followed by mandates in 3 states enacting storage targets. ***UK*** has procured 200 MW of BESS through National Grid Enhanced Frequency Response tender in 2016. |
| Lack of awareness of the technology benefits | • **power system and grid integration studies**<br>Cost-benefit studies can help identify policy barriers that may arbitrarily limit storage deployment. These will also indicate the most efficient roadmap for the given system. |

Source: GE Energy Consulting, IHS Markit

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In this document, we sometimes use information derived from consolidated financial data but not presented in our financial statements prepared in accordance with U.S. generally accepted accounting principles (GAAP). Certain of these data are considered “non-GAAP financial measures” under the U.S. Securities and Exchange Commission rules. These non-GAAP financial measures supplement our GAAP disclosures and should not be considered an alternative to the GAAP measure. The reasons we use these non-GAAP financial measures and the reconciliations to their most directly comparable GAAP financial measures are posted to the investor relations section of our website at www.ge.com. [We use non-GAAP financial measures including the following:

- Operating earnings and EPS, which is earnings from continuing operations excluding non-service-related pension costs of our principal pension plans.
- GE Industrial operating & Verticals earnings and EPS, which is operating earnings of our industrial businesses and the GE Capital businesses that we expect to retain.
- GE Industrial & Verticals revenues, which is revenue of our industrial businesses and the GE Capital businesses that we expect to retain.
- Industrial segment organic revenue, which is the sum of revenue from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial segment organic operating profit, which is the sum of segment profit from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial cash flows from operating activities (Industrial CFOA), which is GE’s cash flow from operating activities excluding dividends received from GE Capital.
- Capital ending net investment (ENI), excluding liquidity, which is a measure we use to measure the size of our Capital segment.
- GE Capital Tier 1 Common ratio estimate is a ratio of equity