SPECIAL TRACK
SEA: Smart Energy Applications

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Proposers

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  - Research Interests:
    - Electronic Design Automation
    - Digital Systems
    - Efficient Machine Learning
  - Author of ≈ 40 papers on these subjects

- **Prof. Massimo Poncino**
  - Full Professor of Computer Eng. at Politecnico di Torino
  - Research Interests:
    - Digital systems
    - Energy systems
    - Electronic Design Automation
  - Author of 400+ papers on these subjects
  - Fellow of the IEEE
SEA: Smart Energy Applications

- Adding smartness to energy systems relies on a set of enabling technologies to achieve an intelligent and efficient use of energy that enable a set of smart “services”.
  - New materials and devices for efficient generation, transportation and storage of energy
  - Fast and reliable connectivity to enable interaction among different parts of a grid, possibly using an Internet-of-things (IoT) paradigm
  - Efficient and accurate simulation models and engines to allow early prototyping of these systems,
    - Possibly allowing the concurrent simulation of devices, connectivity and software within the same framework.
SERVICES enabled by these enabling technologies include, just to name a few:

- real-time monitoring of energy consumption (e.g., through smart meters)
- energy balancing and management in the grid at the building- or district-level
- predictive identification of faults due to aging components
- efficient integration of (possibly distributed) renewable sources
- ...
Smart Energy is *hot*

- Top priority in several research programs in the European Union (Horizon2020, ECSEL, EPoSS),
  - A natural follow-up of the 2015 Paris Agreement, which set an ambitious direction for investment into low-carbon innovation.

- A number of measures have been proposed to achieve this goal, mostly with an emphasis on the “green” perspective of energy,
  - E.g., the ’Clean Energy for all Europeans’ package of measures of 2016 which pursues three main goals:
    - energy efficiency
    - leadership of Europe in renewables,
    - a fair deal to consumers
SEA Special Track: contents

1. Yukai Chen, Sara Vinco  
   Politecnico di Torino, Italy  
   “The importance of Accurate Battery Models for the Power Assessment in Smart Energy System”

2. Donkyu Baek  
   Chungbuk National University, Korea,  
   “Powertrain Modeling and Range Estimation of The Electric Bus”

3. Sangyoung Park, Andrea Cominola  
   TU Berlin, Germany  
This work generalizes a smart energy system as the interaction of four main general modules: **power sources, energy storage, loads, converters**.

When the battery acts as the main source of power, there is not a perfect 1:1 match between battery power and load power.

This work adopts an accurate circuit equivalent battery model to achieve a more accurate power assessment.

Two different scales energy systems are presented:
- An IoT multi-sensor node (mW scale)
- A smart house applications (kW scale)
- Fast but accurate electric bus powertrain modeling
  - Step 1: implement vehicle model in complex vehicle simulator
  - Step 2: implement equation-form power model
- Case study 1: power estimation in online
- Case study 2: energy efficiency analysis by battery size
Paper #3

RESEARCH CHALLENGE
Smart meters coupled with Non-Intrusive Load Monitoring (NILM) allow to cost-effectively disaggregate household electricity usage in individual appliance usages. But this generate privacy concerns: how much control will one have over what is being analyzed (electricity usage behavior)?

RESEARCH CONTRIBUTION
We investigate the cost-effectiveness of the potential usage of a residential energy storage for privacy protection against Non-Intrusive Load Monitoring (NILM) algorithms:
- Battery storage can hide the true usage profile. Water-filling hides all privacy information
- Completely flat profile is incompatible with smart grid and requires an excessively large battery size

KEY RESULTS
- Larger number of appliances → slightly less accurate NILM.
- Appl. flattening or water-filling → do not necessarily reduce NILM accuracy and requires big battery capacity.
- Further analysis is required to leverage the trade-off and include variable costs and battery aging.
Perspectives

- Smart Energy encompasses a number of technologies that enable various smart services.
- By optimizing energy management (*generation, storage, distribution, consumption*) at different scales, these services can contribute to the objectives of clean energy and sustainability.
- Papers in this Special Track have featured both with technologies and services as a sample of the wide scope of the research topics under the “smart energy” umbrella.