西安交通大学
XI'AN JIAOTONG UNIVERSITY

PEREC 电力电子与新能源技术研究中心
Power Electronics & Renewable Energy Center

The Role of Power Electronics and the Quest for a Plug-and-Play Grid-Organizing Framework

Jinjun Liu

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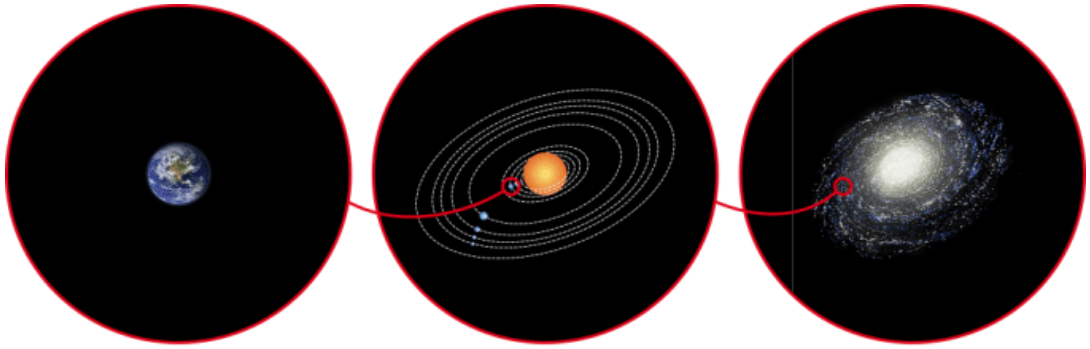
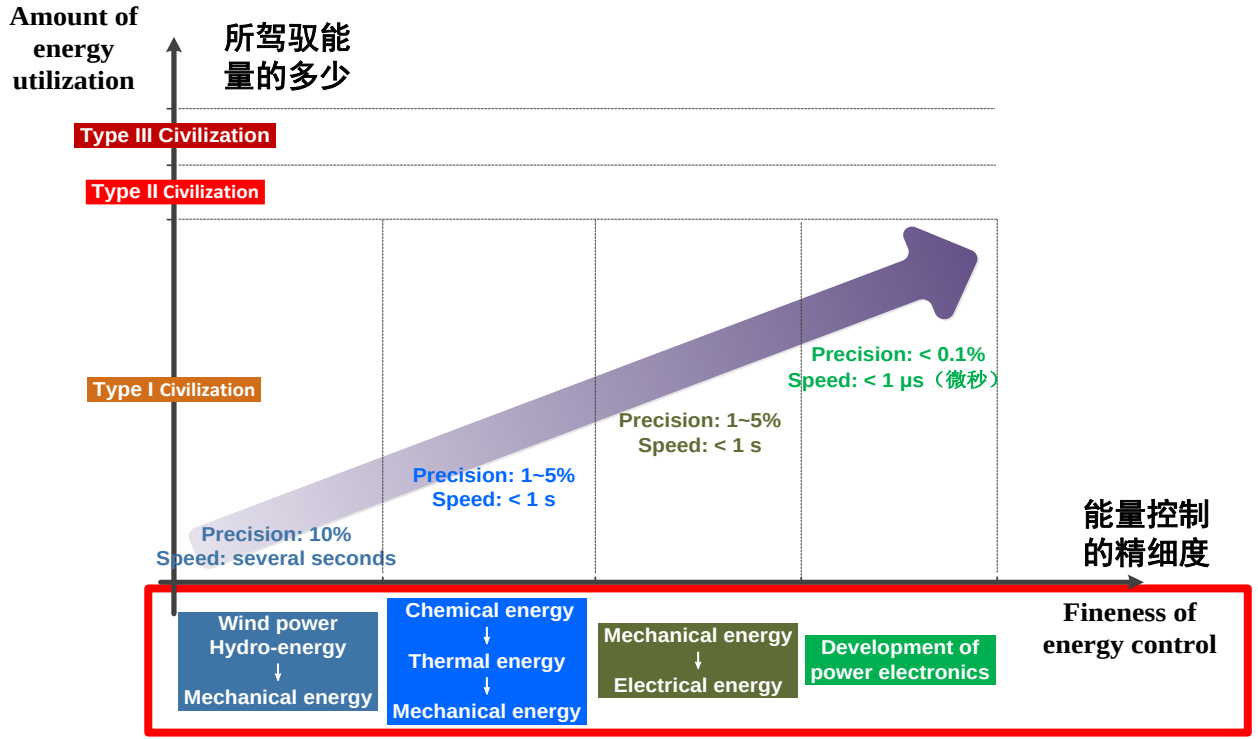
Position of Human Community in Terms of Development Degree of Civilization



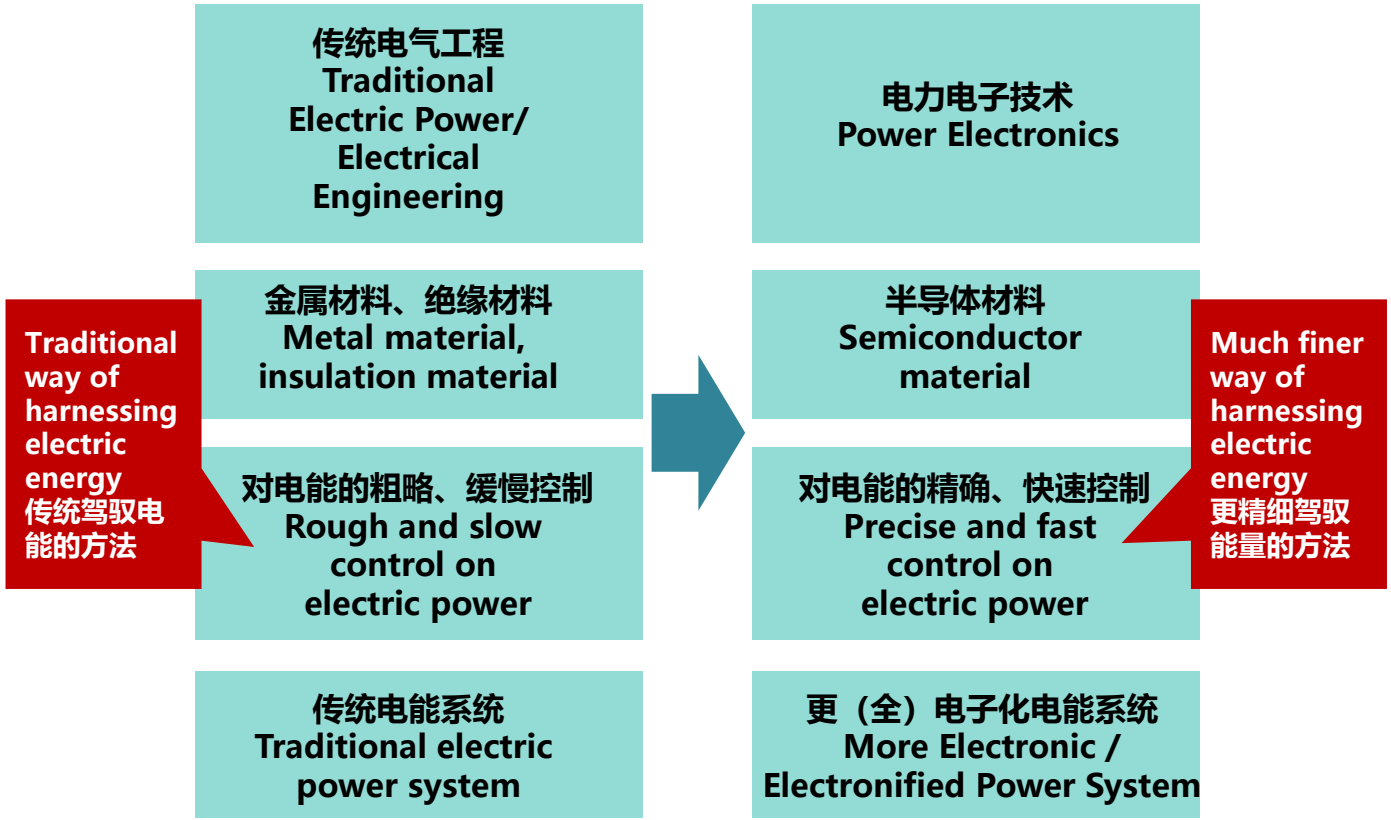
- **Scaling Civilizations according to Amount of Energy Usage: Kardashev Scale**
  - **Type I Civilization:** harness the energy on a single **planet**
  - **Type II Civilization:** harness the energy from a single **star**
  - **Type III Civilization:** harness the energy in a single **galaxy**

Position of Human Community in Terms of Development Degree of Civilization

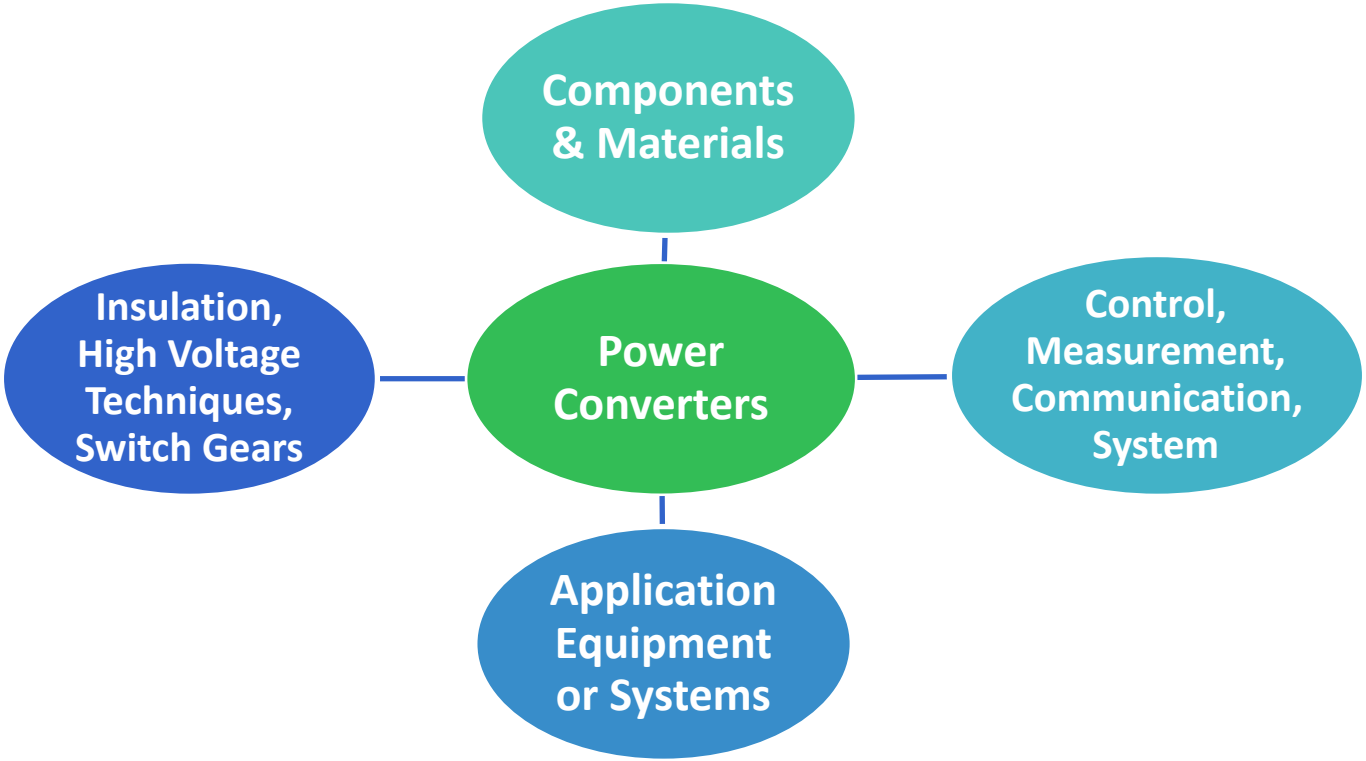
Another Scale of Civilizations: Fineness of Energy Control



Power Electronics Drives Human Society to a New Stage of Civilization



Playing a Core Role in Electric Energy Control and Conversion with Other Energies



Energy conversion between electric and "X" :
Electric, Mechanical, chemical, photo, piezo, thermal, biological, pulsed power

A Same Kind of Challenge to Power Electronics as to Other Area

- Continuous pursuing of better power electronics products
  - Higher performance specs
  - Lower power losses
  - Smaller volume and weight
  - Lower cost
  - Higher reliability
  - Better manufacturability
  - Less negative influences
  - Lower CO_2 emission

“Lipstick” Power

“Cookie” Power

Other challenges to power electronics

- Other challenges
  - A combined methodology to handle both lumped circuits and EM fields
  - Reliability
  - Protection strategy and techniques for future grids
  - Plug-and-play grid-organizing framework

Plug-and-Play Grid-Organizing Framework

- The merits of today's power systems

  A few big non-electronic producers dominate a grid

  - Plug and play
  - Does not usually need real-time communications

  - Steady-state operating point determined by
    - Loaded/regenerated power of each load and small producer
    - Coordination among the big producers
  - Stability determined by the big producers

Plug-and-Play Grid-Organizing Framework

- The really critical challenge for more electronic future power systems
  - High ratio of big electronic producers at large grid level
  - Numerous small electronic or non-electronic producers, consumers, and prosumers at micro-grid level
  - Frequent disconnection and re-connection between micro-grid and large grid

To develop a framework of techniques and standards specifying structure and working state of micro-grids, and terminal characteristics of each electronic producer/ consumer/ router to preserve the merits of traditional grids

Plug-and-Play Grid-Organizing Framework

- To ensure
  - Coordinated steady-state operating points of all the producers
    - Coordinative control for producers to ensure adequate power sharing and, if in islanded mode, voltage and frequency regulation
  - Stability
  - Smooth and fast transfer of micro-grids between islanded mode and grid-connected mode
  - Plug and play
  - NOT rely on communications → autonomous
  - Compatible with non-electronic part

Summary

- Power electronics is driving human civilization to a new era
- Quite a lot of opportunities arise for power electronics related and inter-disciplinary technical research and development as power electronics lies in an inter-linking core position in production chain and neighborhood disciplines
- The quest for a Plug-and-Play Grid-Organizing Framework is very critical for more electronic future power systems

Thank you!

For questions, contact me at jjliu@xjtu.edu.cn

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西安交通大学电气工程学院
School of Electrical Engineering Xi'an Jiaotong University