Wireless Vehicle to Grid Systems: Recent Technological Advances

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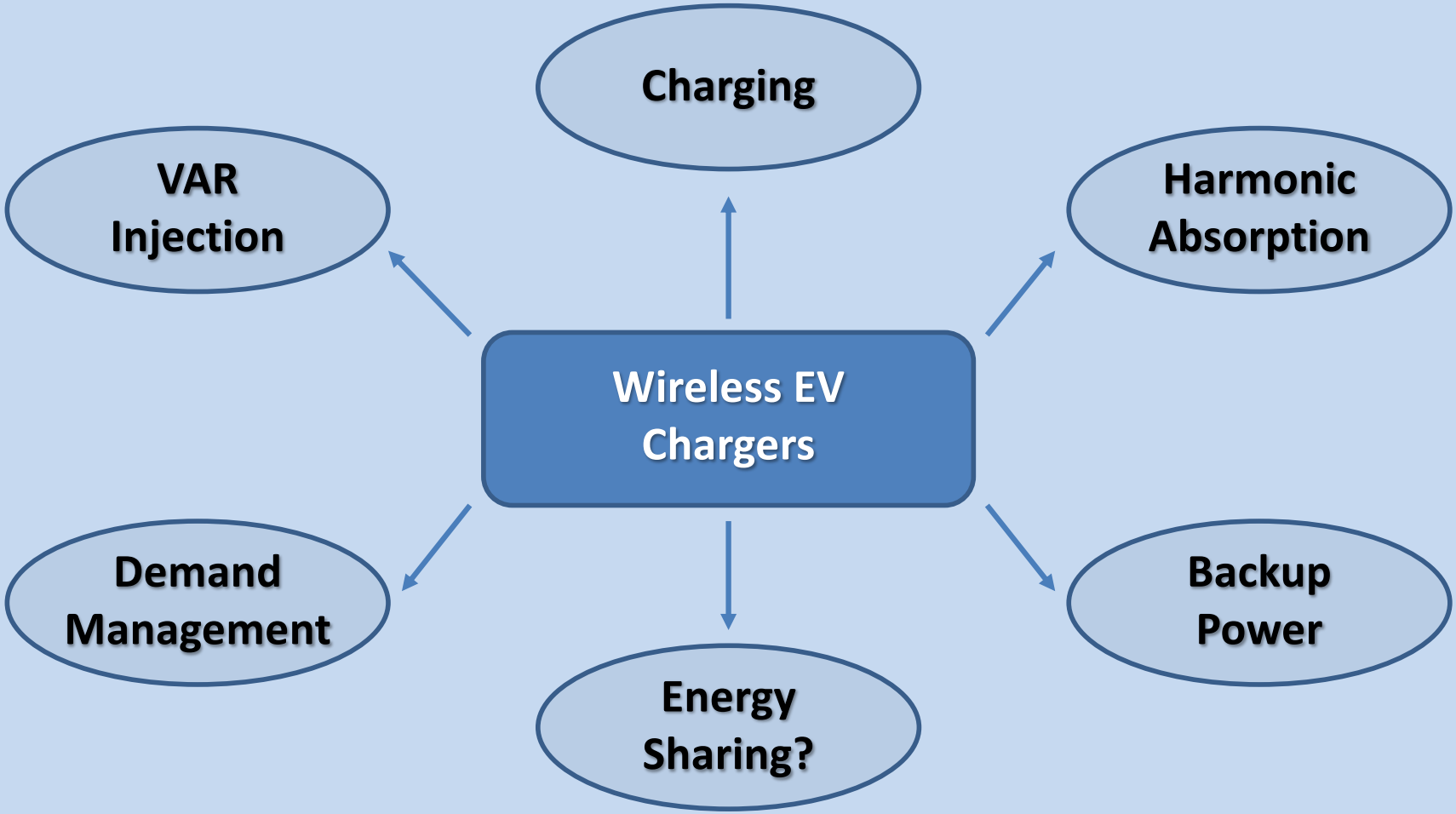
Wireless EV Chargers: Future



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V2G Challenges & Progress

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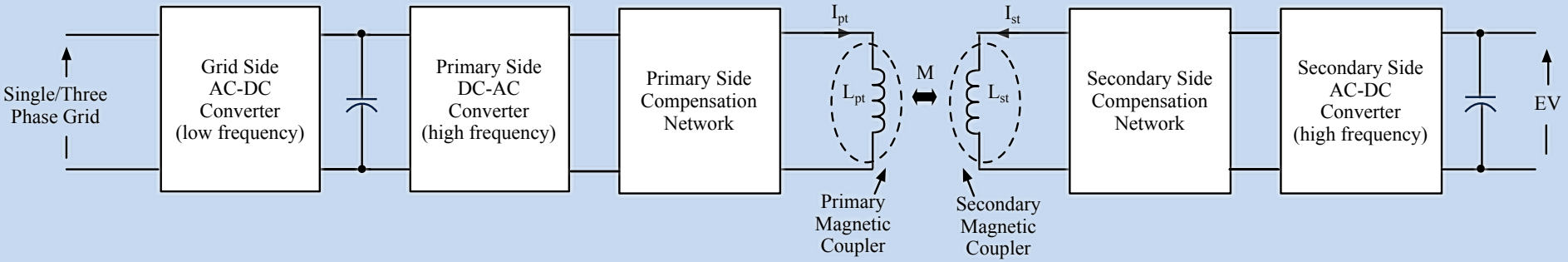
- Efficient and cost effective circuit topologies
  - Promising novel designs are investigated
- Spatial tolerance
  - Improved magnetic deigns and tuning topologies that are tolerant to misalignment are under development
- Policies and standards
  - Significant progress made with regards to wired V2G systems leading to new policies and standards in the future
  - Examples include EDISON, SPIDERS and MeRegioMobil projects
- Effective energy management methods
  - Still at early stages – recent efforts include for example V2G-Sim
- Battery life
  - Hybrid storage systems have been developed to minimize cycling of batteries
  - Promising battery technologies?

Bi-Directional WPT Systems

- Bi-directional WPT systems are critical for implementing V2G services
  - Uni-directional systems have very limited capabilities
- Most popular topologies are
  - H-bridge VSI based LCL-LCL topology
  - H-bridge VSI based series-series (CL-CL) topology
  - Push-pull CSI based LC-LC topology
- Phase-shift between converters regulates both the magnitude and direction of power flow
  - VSI may use pulse width modulation techniques to regulate the magnitude of power flow
- Grid-frequency inverter provides a bi-directional power interface with the grid



A typical wireless V2G system

BD-WPT Current State

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- DC-DC efficiency of commonly reported BD-WPT systems are in the range 92% to 96%
  - Within the X, Y, Z operating region
  - Higher efficiency and spatial tolerance in comparison to UD-WPT at the expense of control complexity
- Mostly WPT1 to WPT3 level systems
  - High-power stationary systems have been demonstrated
- Although direct AC-AC primary converters have been developed two stage AC-DC-AC approach preferred
  - Power ripple leads to poor efficiency and higher EMI
- Limited V2G services illustrated
  - Mainly grid feeding
- Synchronization techniques that enable seamless bi-directional power transfer has been demonstrated
  - Robustness of the closed loop controllers still need investigation
- Energy sharing capabilities have been demonstrated
  - Lower efficiency due to double-coupled system topology

A Comparison

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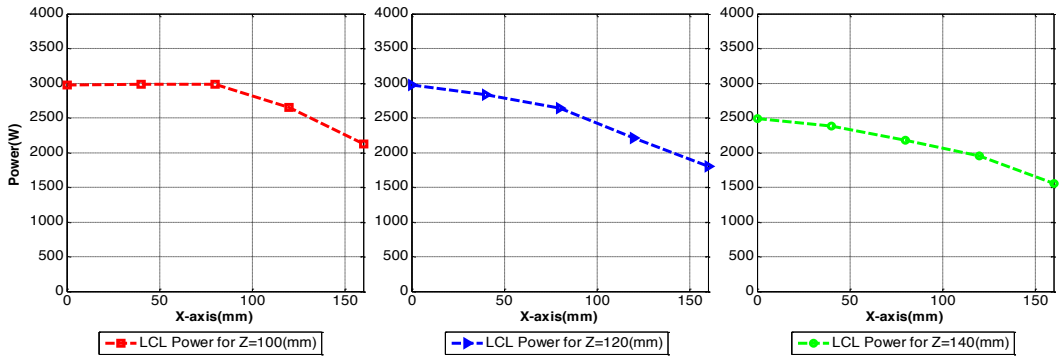
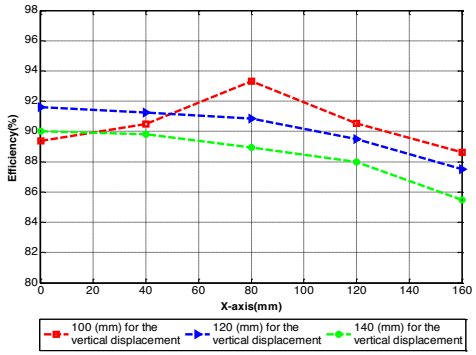
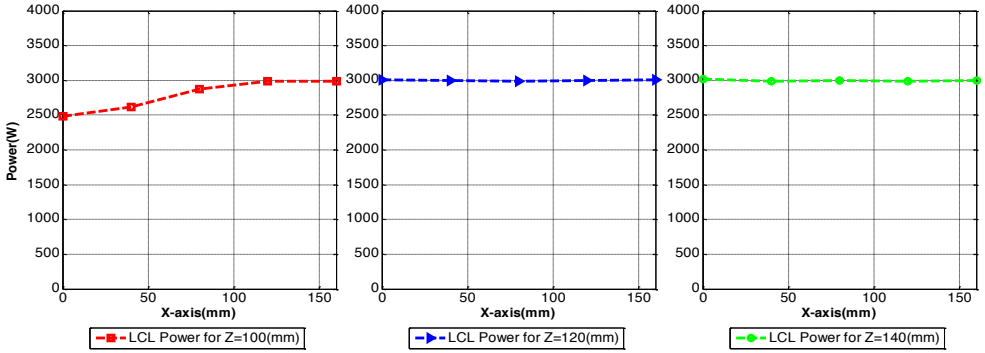
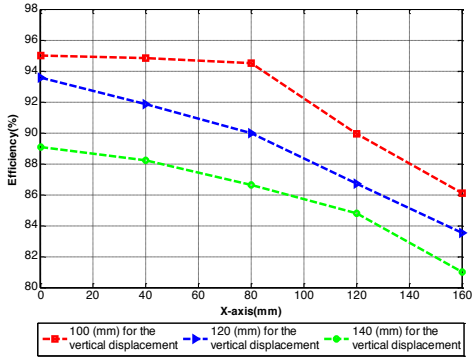
H-Bridge
+
LCL-LCL



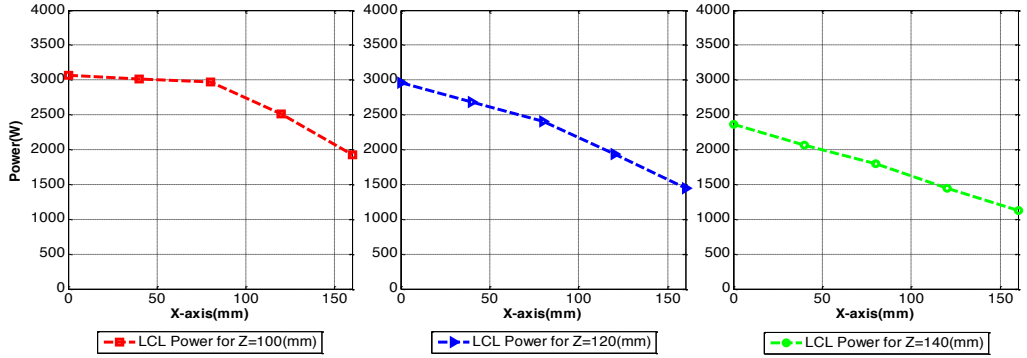


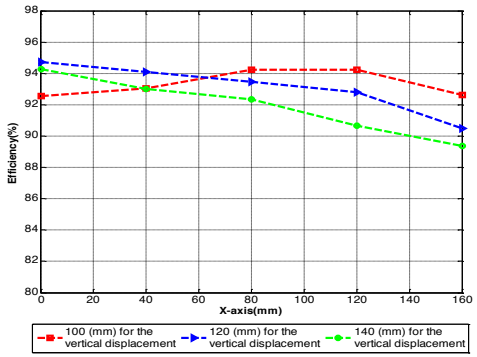
H-Bridge
+
CL-CL





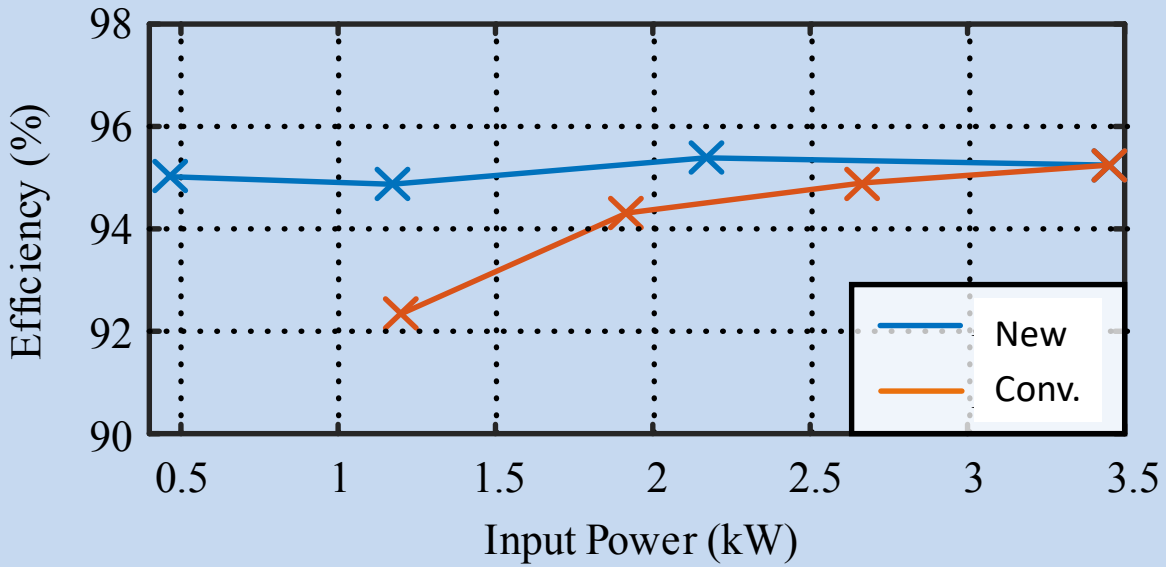
PPRC
+
LC-LC





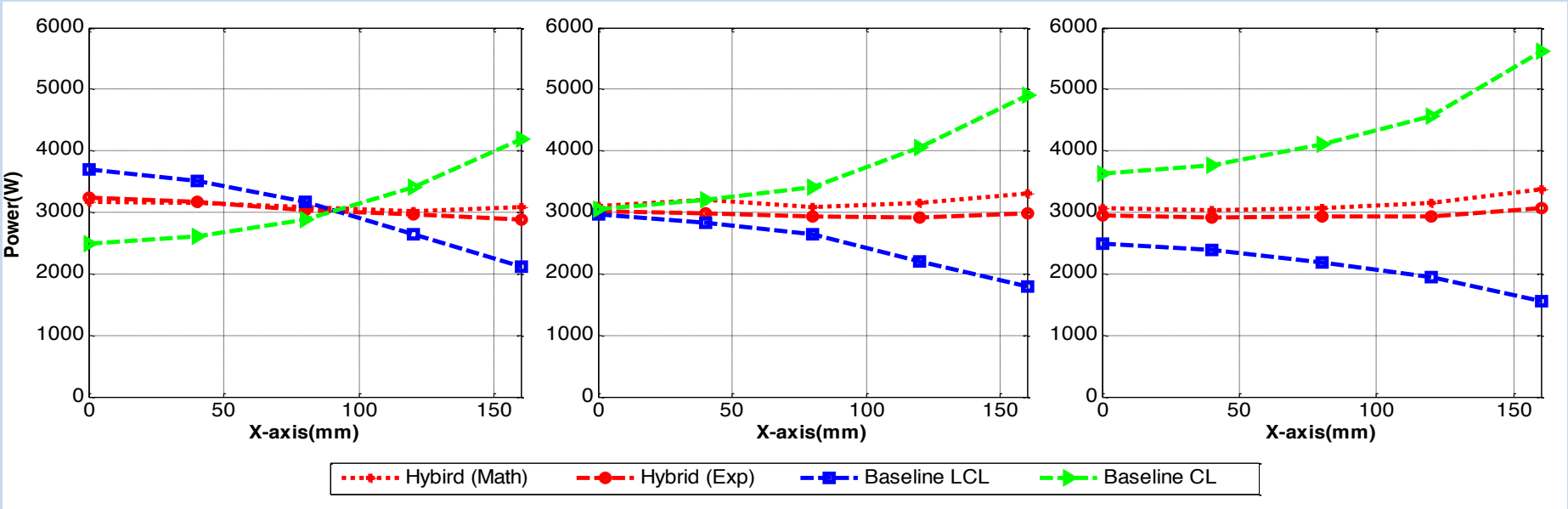
New Developments at UoA

Active DC-Link Control



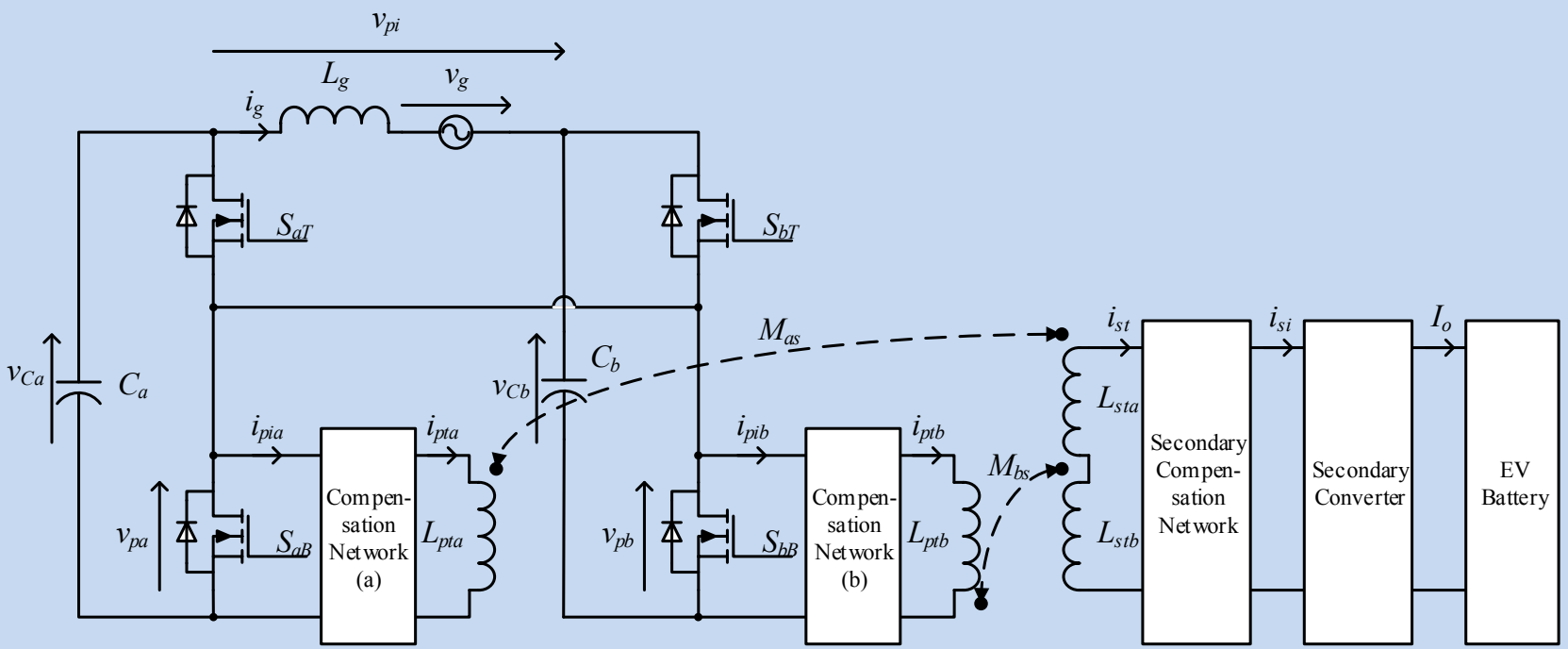
- DC-link actively controlled
  - Does not require additional switching devices
  - Suitable for VAR injection and harmonic compensation
    - ✓ While reducing size of DC-link
- Improved efficiency and misalignment tolerance
  - Especially partial load efficiency

New Compensation Methods



- Higher order tuned circuits and coupled magnetics to achieve a system immune to misalignment
  - Maintains a near constant output power
  - Reduces VAR loading under misaligned conditions
- Simplify control and improves efficiency under misalignment
  - Example shown above for a fixed duty-cycle controller

Direct Grid Integration



- Employs two half-bridge converters for direct grid integration
  - Reduced number of conversion stages and eliminates large DC-link
- Enables bi-directional power flow
  - Low cost implementation of V2G services