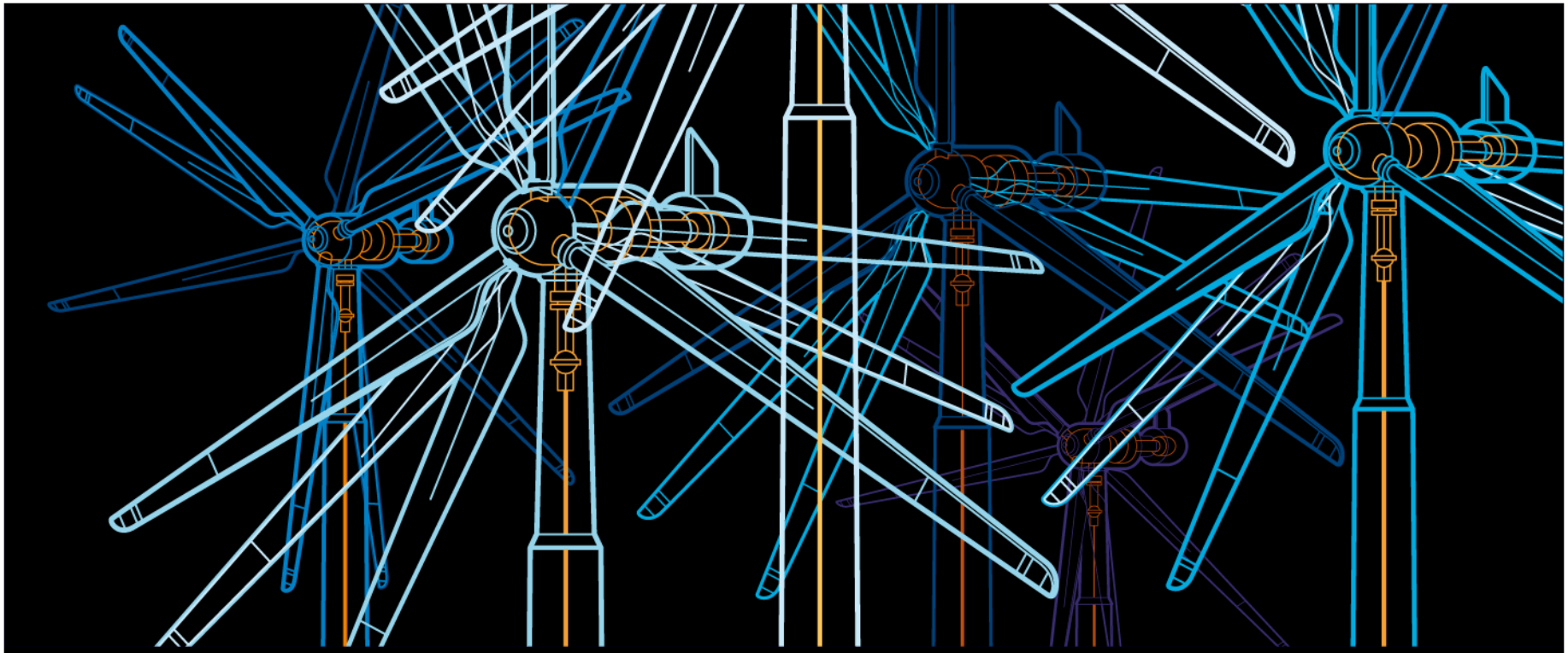
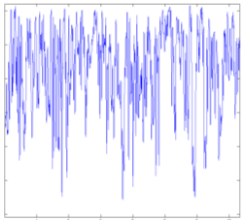


IRENA Innovation Week, Bonn, May 11-13, 2016 – Jochen Kreusel

Deep dive on future grid
Smart grid technologies

Properties of renewable generation
Fundamentally new challenges for power systems



Variable and uncertain generation

Maximum output varies depending on wind and sunlight
No perfect forecast for wind and sunlight available

Inertial response capability

Non-synchronous generation technologies connect to grid via power electronics and have little or no inertial response capability

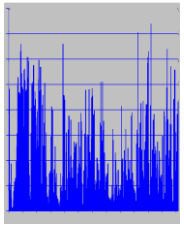
Location constrained

Areas with the best resources are often situated in remote locations. Tapping into these resources will require efficient ways to transport a large amount of power over long distances

Modularity

Renewable power generation can be found as residential or commercial size. Increasing levels of distribution level generation will require new approaches to regulate and manage this energy

Renewable integration
Technological building blocks

Driver		Conv. generation	Transmission	Distribution	System operation	Application
Locational constraints			▪ FACTS[1] ▪ Long dist. transm. ▪ Overlay grid/ HVDC		▪ Stabilization with FACTS[1]	
Modularity, distributed-ness				▪ Automation ▪ Voltage regu-lation (grid) ▪ Voltage sup-port (gen.)	▪ Communi-cation ▪ Control ▪ VPPs[2]	
Variability and uncentainty		▪ High effi-ciency all over output range ▪ Flexibility	▪ Trans-regional leveling ▪ Overlay grid/ HVDC ▪ Bulk storage	▪ Distributed storage	▪ Demand response ▪ VPPs[2] ▪ PMU/WAMS[3]	▪ Storage (in applications) ▪ Demand response
Lack of inertial response capability		▪ Faster activation of FCR[4]	▪ Fast storage	▪ Flywheels ▪ Fast storage	▪ Faster response of FCR[4]	▪ Demand response (frequency response)

[1] FACTS: Flexible AC Transmission Systems
[2] VPP: Virtual Power Plant
[3] PMU/WAMS: Phasor measurement units/wide area monitoring systems
[4] FCR: Frequency Containment Reserve

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