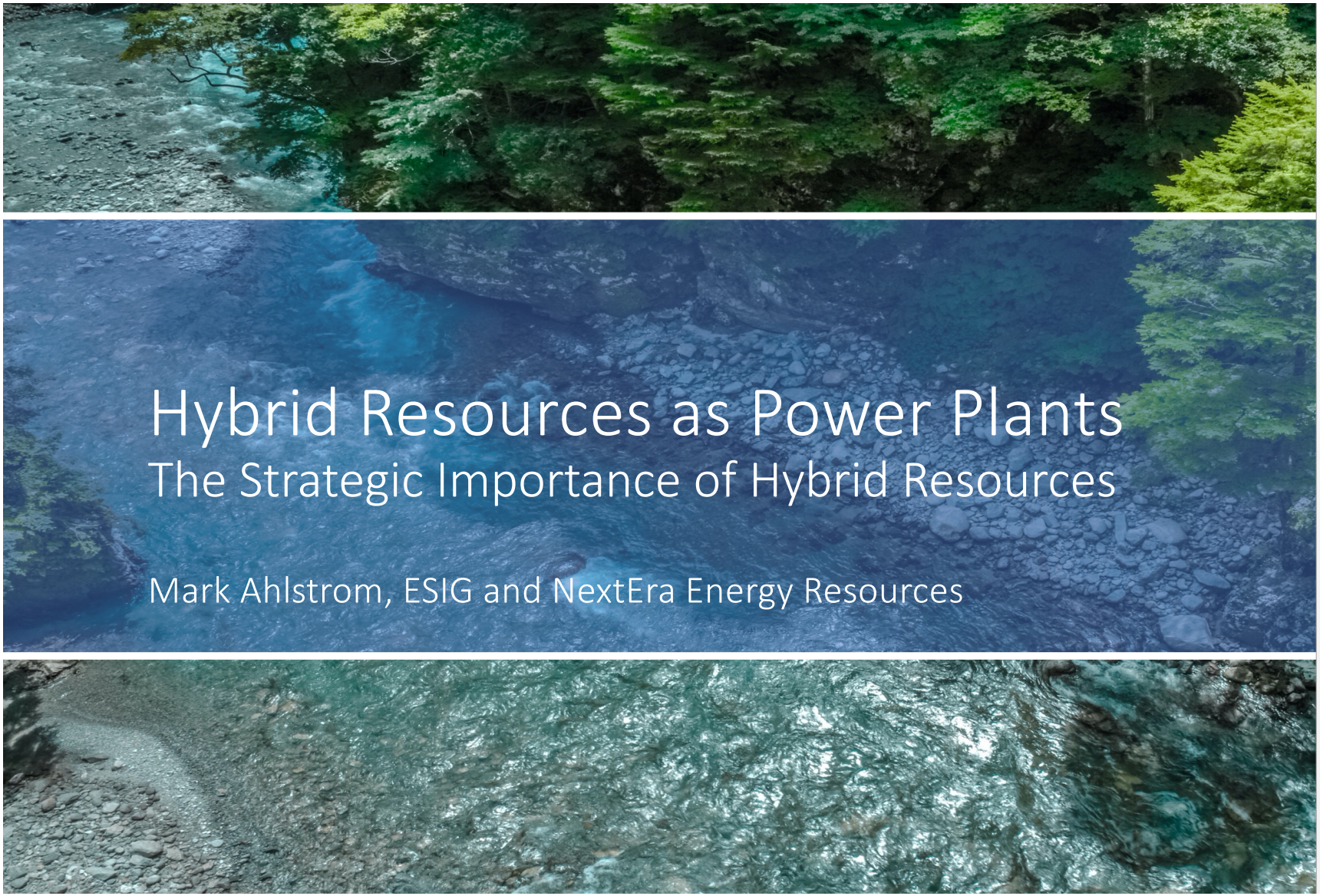


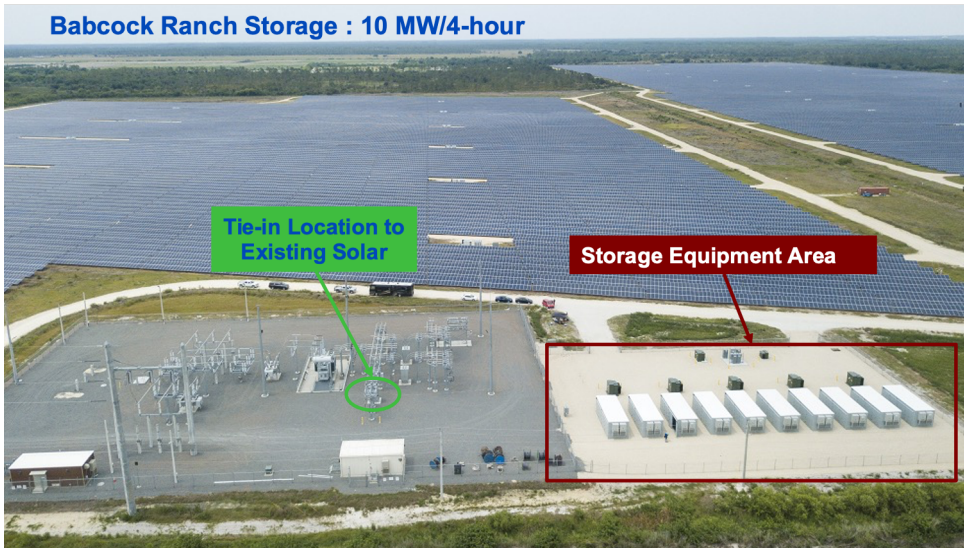
Hybrid Resources as Power Plants

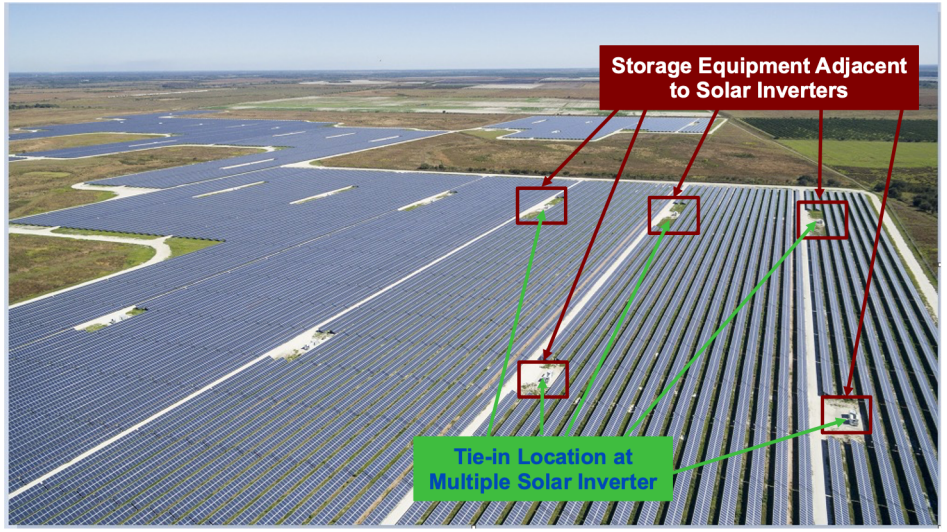
The Strategic Importance of Hybrid Resources

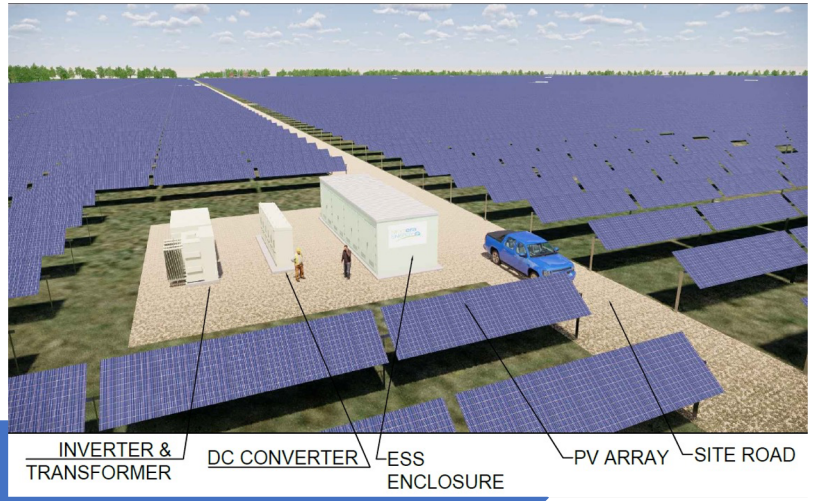
Mark Ahlstrom, ESIG and NextEra Energy Resources

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Hybrids are Real
(AC- and DC-coupled)

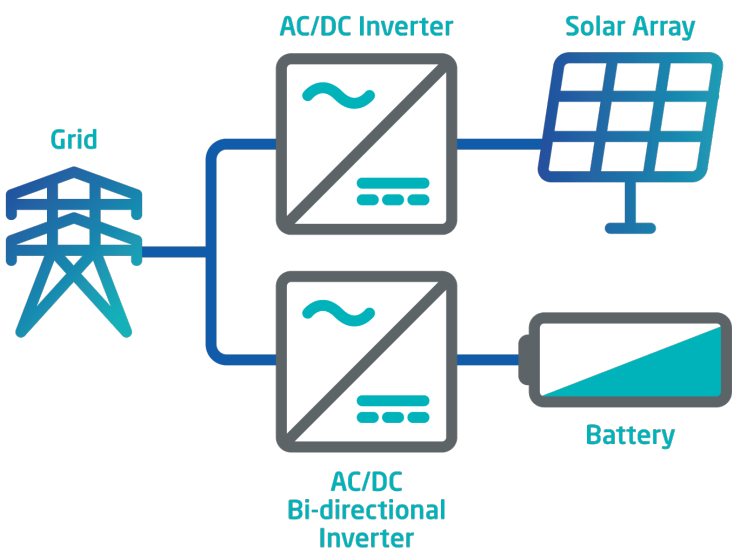




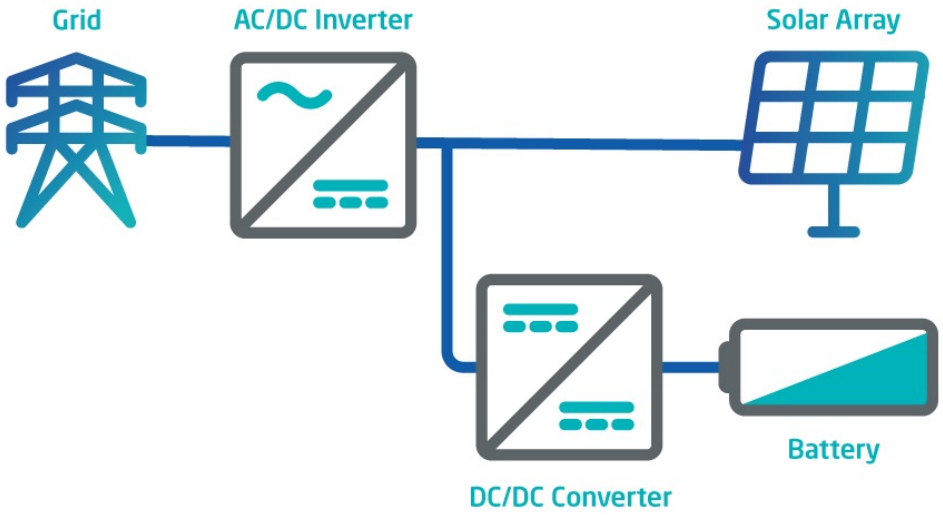


AC-coupled and DC-coupled – Solar PV + Storage Example

AC-coupled (Hybrid or Co-Located Resource)



DC-coupled (Hybrid or Co-Located Resource)



Hybrid Resources – Definition

A combination of multiple technologies that are physically and electronically controlled by the Hybrid Owner/Operator behind the point of interconnection ("POI") and offered to the grid as a *single resource* at that POI

If treated as multiple technologies, it is "co-located" rather than "hybrid"

The "aggregated resources" family of software-based resources:

- Co-located Resource — treated as multiple "known" technologies sharing a POI
- Hybrid Resource — treated as a single resource offering services at the POI
  - Aggregated DER — a Hybrid Resource using a population of DERs
  - Virtual Power Plant — a general term for all the other Hybrid Resource variants that come next…

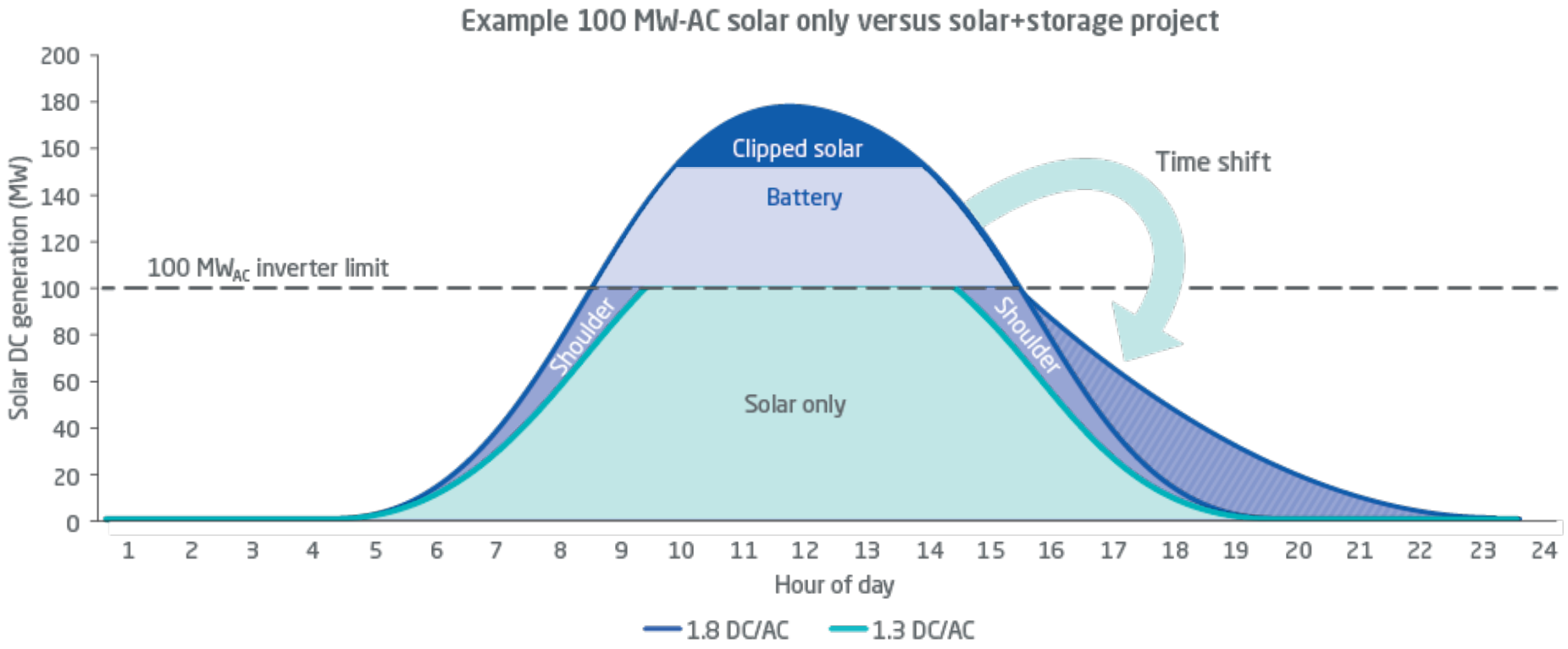
The “True Hybrid” Resources Concept

Uses an “intelligent agent” approach that internalizes the characteristics of the components behind the POI and offers energy and services at the POI like a conventional resource, but with more flexibility and fewer constraints through coordinated use of energy, storage, power electronics and software technologies

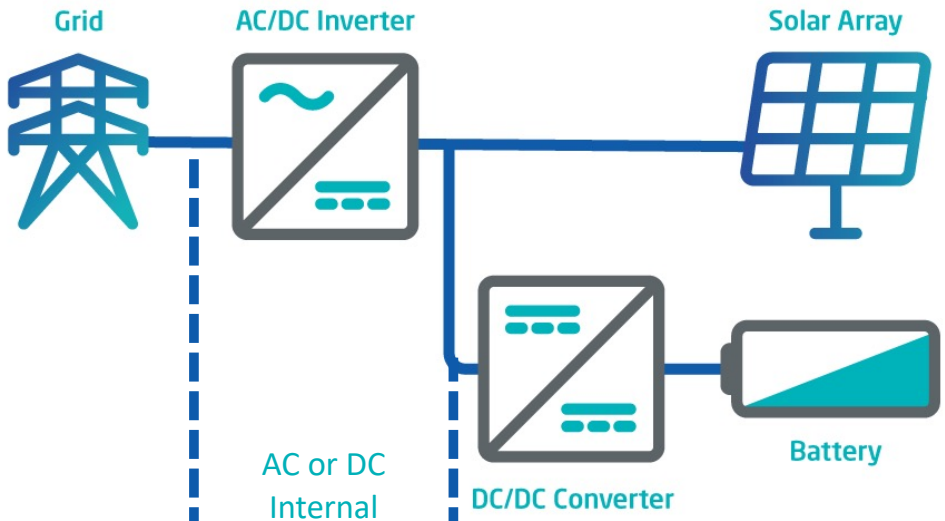
Or said more simply…

With sufficient energy, storage, electronics and software,
we can emulate any kind of electrical machine that we want or need

Maximizing solar with energy storage in a Hybrid Resource



Other trends that are much closer than you think…



Easier to add new technologies into hybrid resources than to directly integrate them in the market software, energy management software and rules

- maintain electrical properties
- enhance offers of services

Aggregated Resource Additions

- Additional generation (cheap, clean, inflexible is ok)
- Additional storage (lower cost, longer duration, slower is ok)
- Controllable loads (H_2 electrolyzers, ammonia, data centers, co-generation)
- Innovative concepts that we haven't quite thought of yet

Key Benefits of Hybrid Resources

Can emulate an existing resource model, but with more flexibility and control

- A renewable plant that can provide other services without retaining headroom to do it
- Like a gas plant that can start instantly and ramp down to zero

Directly managing batteries is complicated – hybrids simplify things for the customer

- The Hybrid manages state-of-charge (through their offers) and optimizes all components
- The system operator or customer sees a simpler interface that more directly matches their needs

In markets, provides a simpler and "more ideal" offer to the market operator

- The storage technology can be charged internally or from the grid—an economic choice
- Fully convex, one-part offers* without advance commitment, startup, or minimum generation

* Monotonically increasing energy offers without startup or no-load fees. For a good explanation of convexity and offers, see: https://www.iso-ne.com/static-assets/documents/2015/06/price_information_technical_session11.pdf

But… What is it?

Is a Hybrid Resource really like a…

- Microgrid
- Distribution System Operator
- Subroutine/function call in a software systems
- Object in object-oriented system architecture

Yes!

Key characteristic: services-level interface that allows the “aggregated resource” to creatively innovate and evolve behind the interface

Services Interface vs Universal Participation Model (UPM)

The motivation for both is to reduce the complexity, delay, cost and risk of fully supporting participation of innovative new technology in the bulk power system

The UPM concept is a parameterized approach (and so is FERC Order 841 for storage)

Hybrid Resources use the services interface approach

Where will new technologies first be deployed at scale?
Within RTO markets/systems, or inside Hybrid Resources, microgrids, behind the meter, etc.?

Mark's Corollary – What's wrong with Order 841 taking a "UPM version 1" approach for storage?

- It treats storage as "only storage" and doesn't inherently support aggregations
- It adds complexity to an already overly complex, top-down, command-and-control approach to using grid resources
- It defers attention on the higher-level service interfaces that will support a more elegant, robust, expanding energy system
- We're now years into talking about storage in markets, and still years to go…

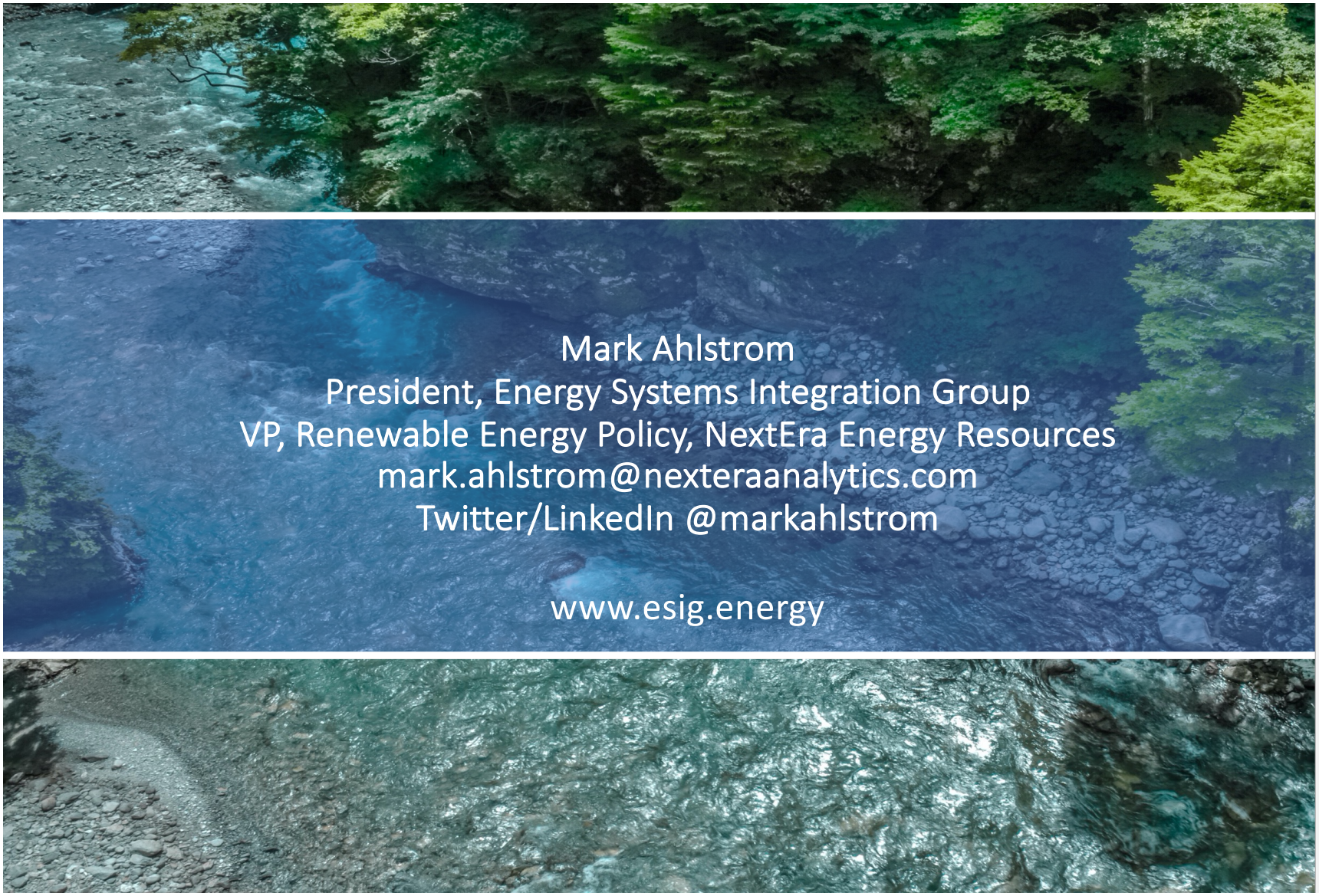
Broader, long-term drivers for Hybrid Resources

Thoughts from a draft paper with Jacob Mays, Eric Gimon, Andrew Gelston, Caitlin Murphy, Paul Denholm, and Greg Nemet to be published in November IEEE Power & Energy Magazine:

- Near term: A response to incentives and delays/costs in the interconnection process
- Maintain (or enhance) desirable operating characteristics of conventional plants while decarbonizing with cleaner and more flexible technologies
- Logical response to complexity and risk – digitalization and decentralization
- Plasticity – modify to pursue valuable services and reduce stranded investment risk
- Market design – simpler, faster, services-based
- Financing – reduced long-term risk translates to lower-cost debt financing
- Technology – enables innovative capabilities of software, electronics and analytics
- Evolution – Hybrids are an early example of intelligent, flexible, aggregated resources that will be increasingly prevalent in future power systems

ESIG – Task Forces & Topics related to Hybrid Resource

1) HyFlex – Hybrids & Emerging Flexible Resources Task Force
   - Transmission Interconnection & Power Flow Modeling for Hybrids
   - Market Rules and Operations for Hybrids
   - Resource Adequacy and Capacity Accreditation for Hybrids
2) System Flexibility Task Force – System Operation & Market Design Working Group
3) Redefining Resource Adequacy Task Force – System Planning Working Group
4) DER Aggregation/Participation Task Force – Distributed Energy Resources Working Group
5) High Inverter-Based Generation Task Force – Reliability Working Group
6) Many other active projects and topics at ESIG
   - Macro grid transmission, operating at very high non-synchronous penetrations, global examples of aggregated DERs and DERMS/DSO concepts, best practices for system operators undergoing grid transformation (core member of the Global Power System Transformation Consortium)



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