Atlantic Wind Connection Update

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Department of Energy Workshop
Applications for HVDC Technologies

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Topics

- Transmission challenges underlying the AWC Project
- Project configuration and technology choice
- The rationale
- Key challenges
- Lessons learned

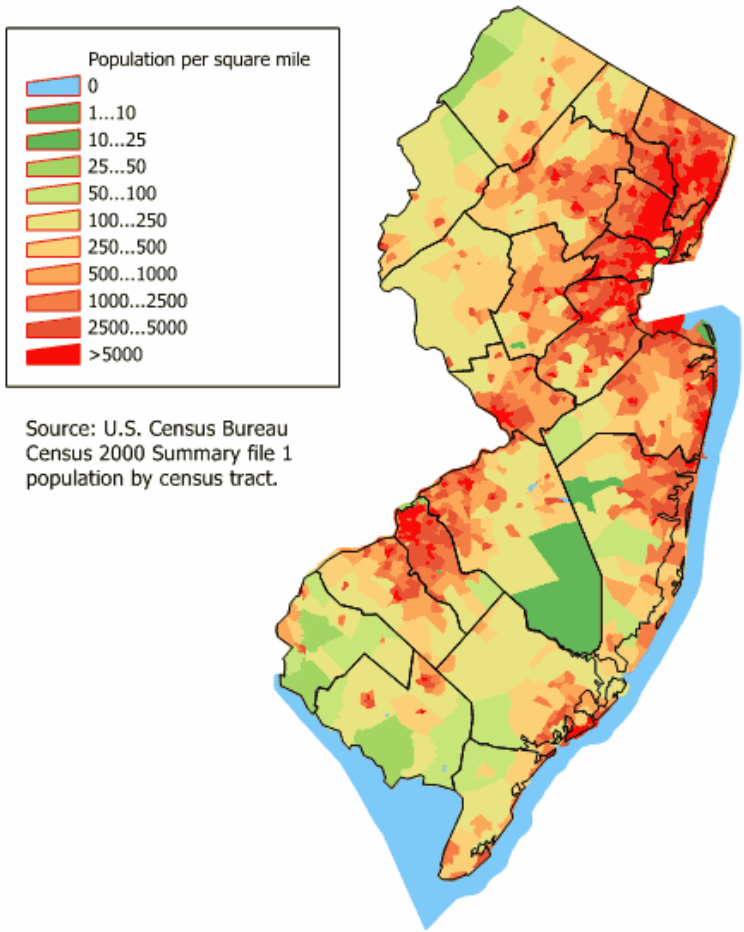
Underlying Transmission Challenges

- Accessing most premium of offshore wind (OSW)
- Locationally constrained resource
- Weak interconnection interface
- Need to minimize cost of delivered OSW energy
- Availability of system benefits

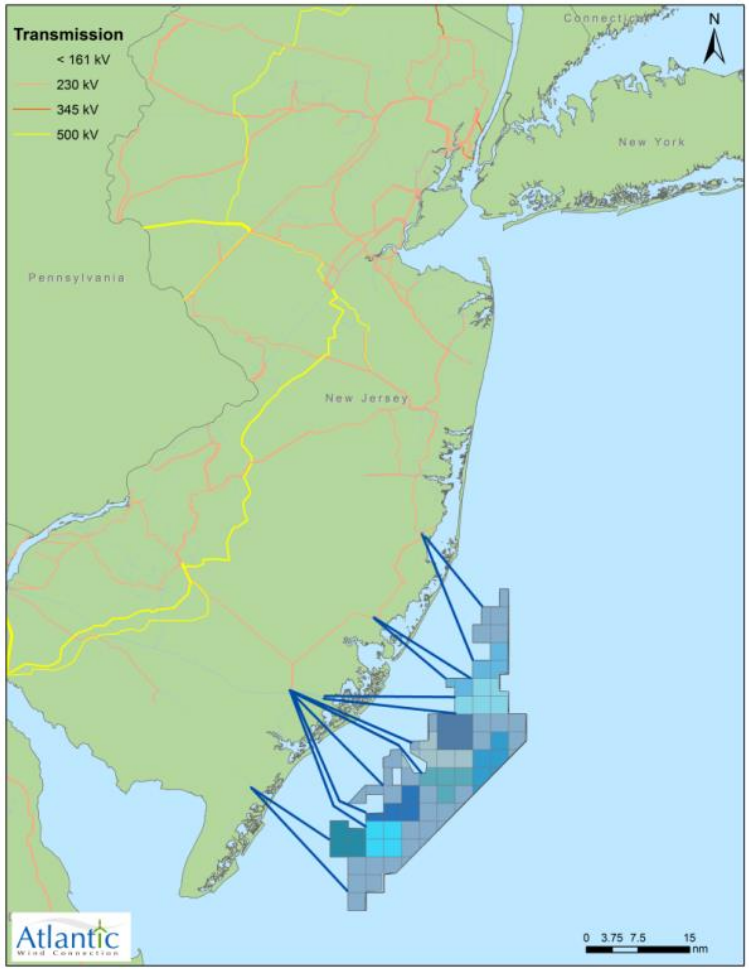
Accessing A Most Premium OSW Resource

- Very high quality wind
- Substantial capacity
- Shallow sea floor
- Proximity to high demand
- Geo-electric appeal

Locationally Constrained Resources



Source: U.S. Census Bureau
Census 2000 Summary file 1
population by census tract.



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Weak Interconnection Interface

- **No 345 or 500 kV backbone east of the I-95 corridor**
- **A 230-kV sub-backbone**
- **A subtransmission network of a largely 69 & 138 kV circuits**
- **With 1 exception – all available Points of Interconnection (POIs) are 230 kV**
- **Adding 500-kVs is impracticable & new 230-kVs very difficult**

Need to Minimize Cost of Delivered OSW Energy

- **Most significant: Enable economy of scale for OSW**
- **Find replacement for radial interconnections**
- **Look for attainable system benefits**

OSW Economy of Scale & Radials Are Incompatible

The Permitting Gantlet

- Coastal Zone Consistency (Coastal Zone Act)
- Coastal Area Facility Review Permit
- Tidelands Conveyance License
- Freshwater Wetlands Permit
- Waterfront Development Permit
- Wetlands Permit
- Flood Hazard Area Permit
- Site Plan Approval (Municipal & County)
- Right to Occupy Highways (Several agencies)
- Other (local/regional agencies & commissions)

Availability of System Benefits

Three categories:

- **Reliability (NERC standards based and other types)**
- **System economic benefits**
- **Engineer for fair cost allocation**

System Reliability Benefits

- **Solution of violations of NERC based criteria**
- **Improving operational performance**
- **Resolving aging infrastructure issues**

System Economic Benefits

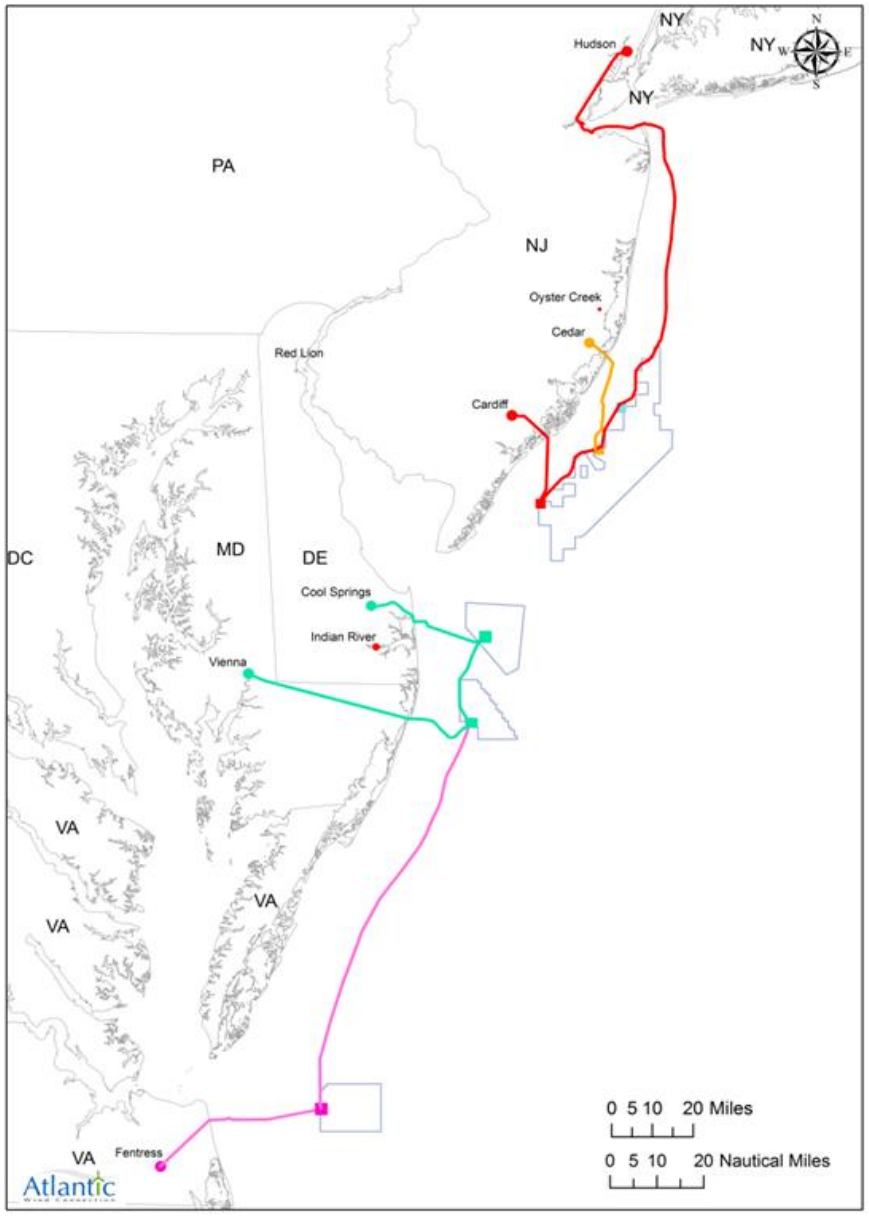
- **Reducing Load Payments**
- **Reducing Production Costs**
- **A new FERC-approved Market Efficiency test**

Engineer for Fair Cost Allocation

- **Order 1000: The Beneficiaries Pay principle**
- **Single-Driver projects**
- **Multi-Driver (MD) investments**
- **Public Policy Requirement (PPR) projects**
- **Regional vs. Non-regional projects**

Project Configuration & Technology Choice

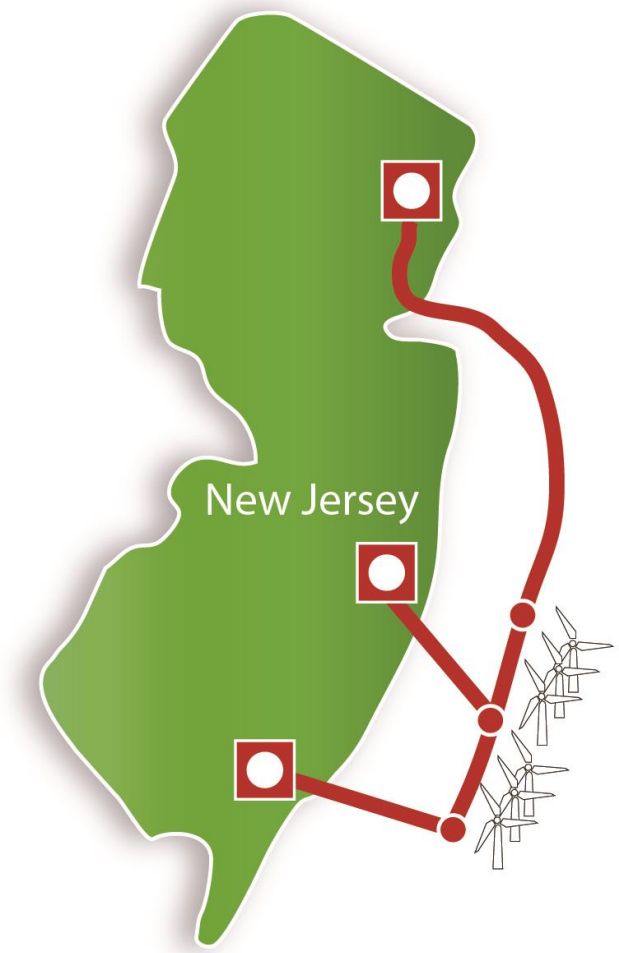
- **The 6-GW Atlantic Wind Connection (AWC) configuration**
- **The NJ Energy Link**
- **Technology choice: Voltage-Sourced Converter (VSC) HVDC transmission with buried cables**



The 6-GWs Atlantic Wind Connection (AWC) Design

- **Initially 2 overlapping circuits**
- **Now 2 in-series circuits**
- **Reduced dc-fault concerns**
- **Phased development**
- **Future inter-circuit ties feasible**

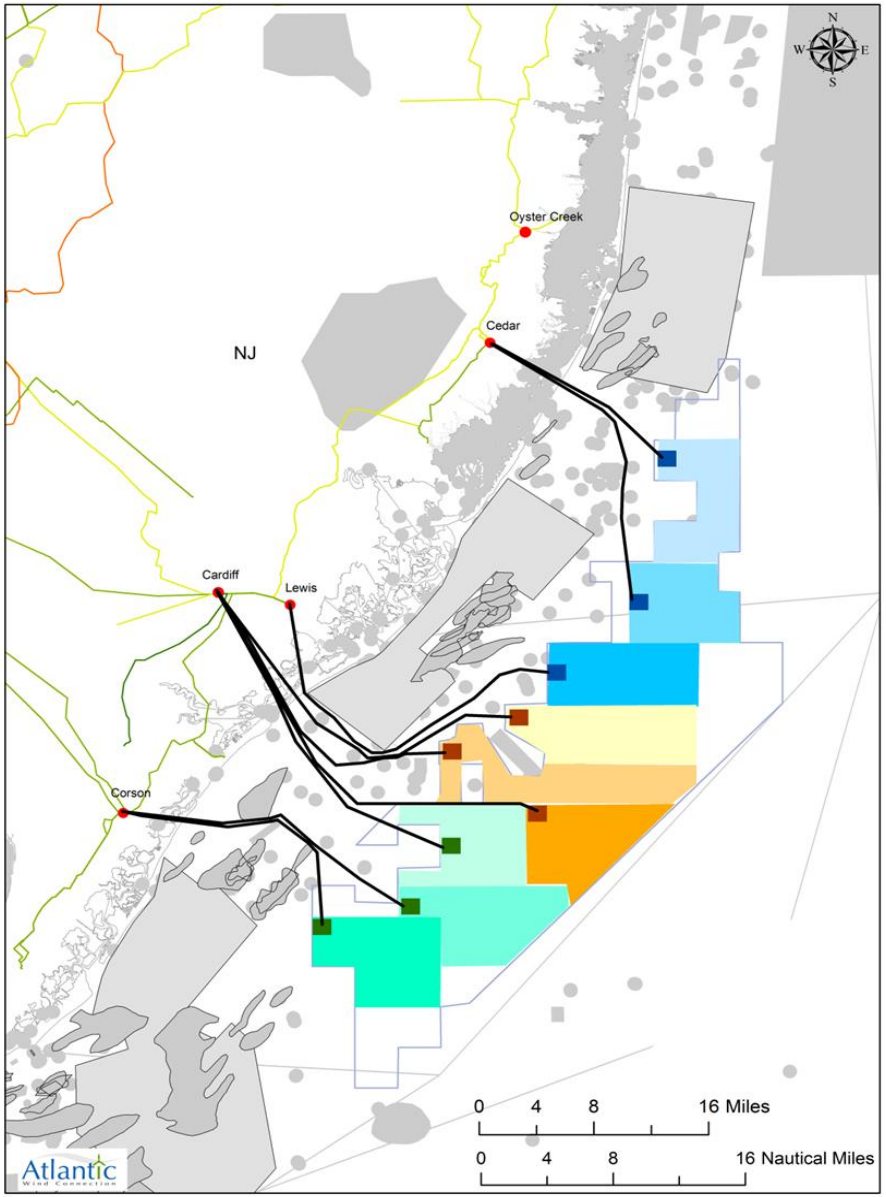
The New Jersey Energy Link



- HVDC network connecting northern, central and southern New Jersey
- Delivers 3,000 megawatts of offshore wind and low-cost energy
- Enough to power 1 million homes
- Strengthens NJ's electric grid
- Reduces cost of offshore wind
- Enables an industry that will:
  - Create 20,000 jobs *
  - Pump $9 billion into NJ's economy *
  - Add $2.2 billion to State and local government tax revenues *

** Study by IHS Global Insight, a leading global economics and analytics firm*

BregalEnergy Google elia Powering a world in progress Marubeni CORPORATION



NJ Offshore Wind (OSW) Resource Base

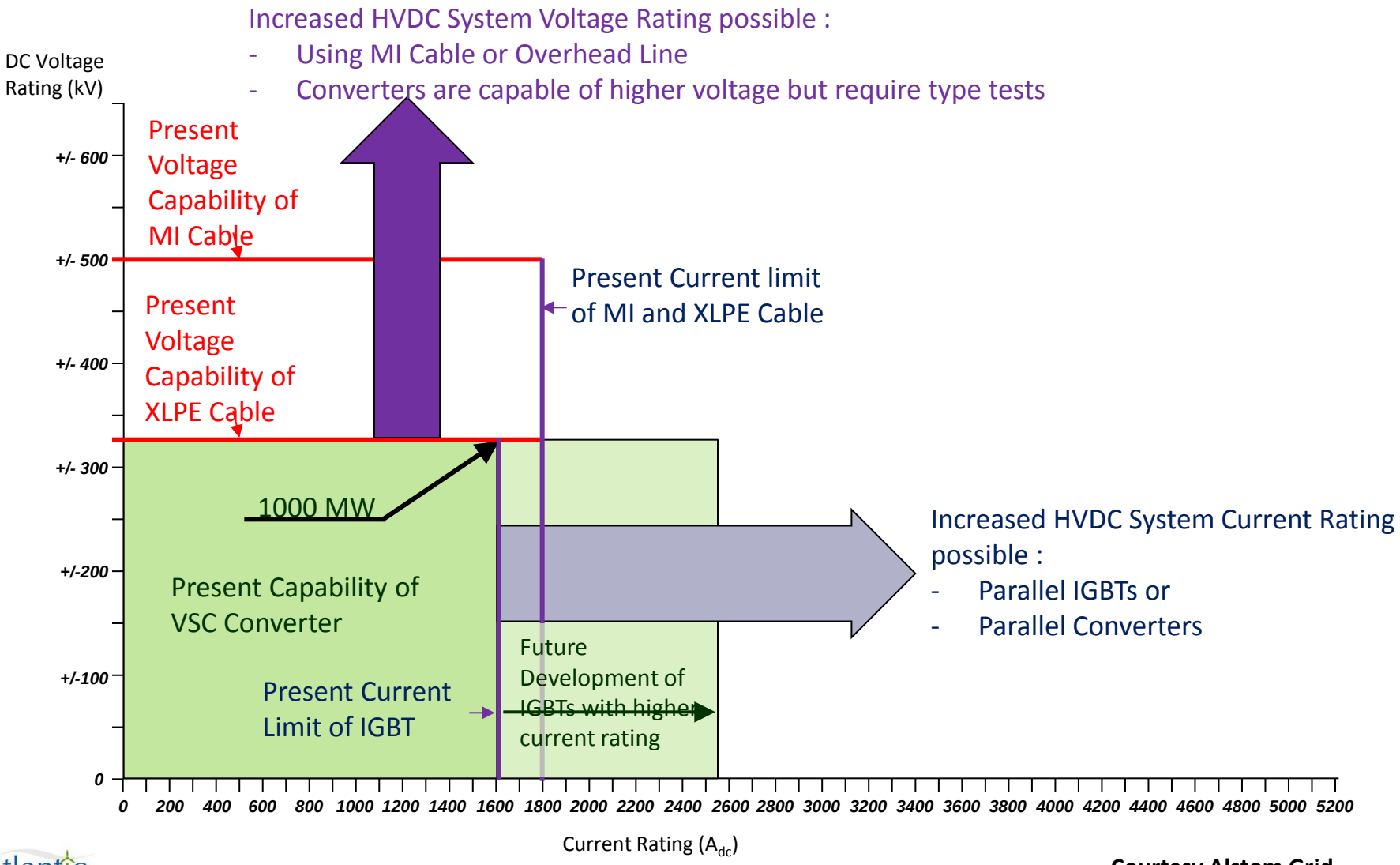
- **NJ Energy Plan: 3000 MWs**
- **9x333 MWs farms**
- **9 radials ties**
- **Or the NJEL: 3x1000 MWs ties**

The Rationale

Seven considerations stand out:

- **HVDC/VSC transmission is indispensable for optimal OSW delivery**
- **Two circuits minimizes the impact of and concerns over dc faults**
- **The NJEL: NJ's substantial commitment to OSW development**
- **Burying cables is essentially unavoidable in much of EMAAC, especially NJ**
- **Currently 230 –kV offers best POIs – 138-kV may trigger extensive upgrades**
- **1000-MW modules are readily available**
- **Half bridge VSC architecture is proven technology**

The VSC-Cable Technology Readiness Envelope



Courtesy Alstom Grid

Key Challenges

- **Project incorporation into PJM's Regional Transmission Expansion Plan (RTEP)**
- **Coordination with OSW development**
- **Cable supply and installation**

RTEP Project Approval

Avenues to RTEP approval:

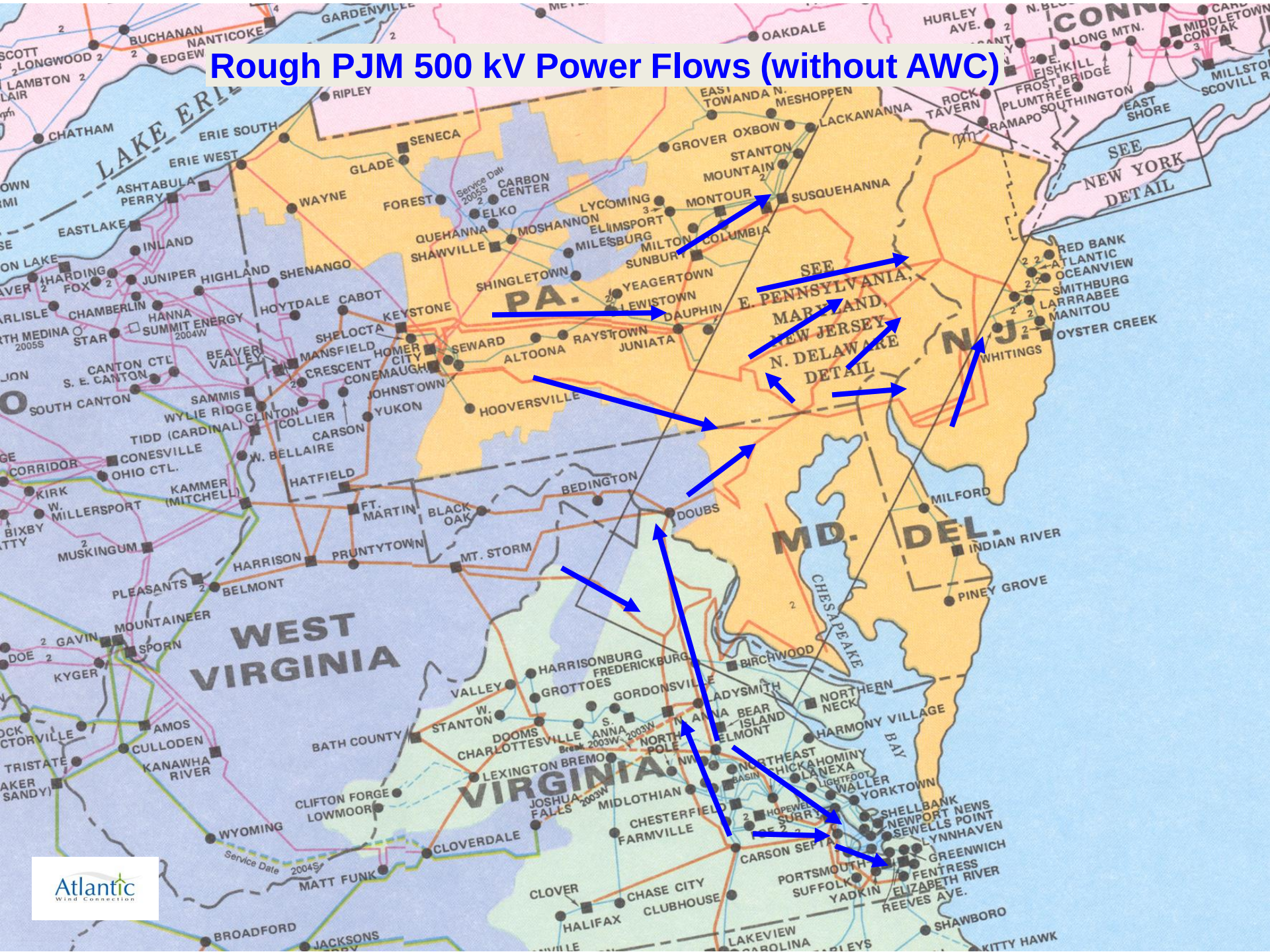
1. Meeting reliability need(s)
2. As a market efficiency project
3. As a state-sponsored public policy requirement (PPR) project
4. A generators collector system (the Tehachapi model)
5. Multi-driver (MD) project combining 2 or more of Drivers 1 thru 4

RTEP Project Approval
(continued)

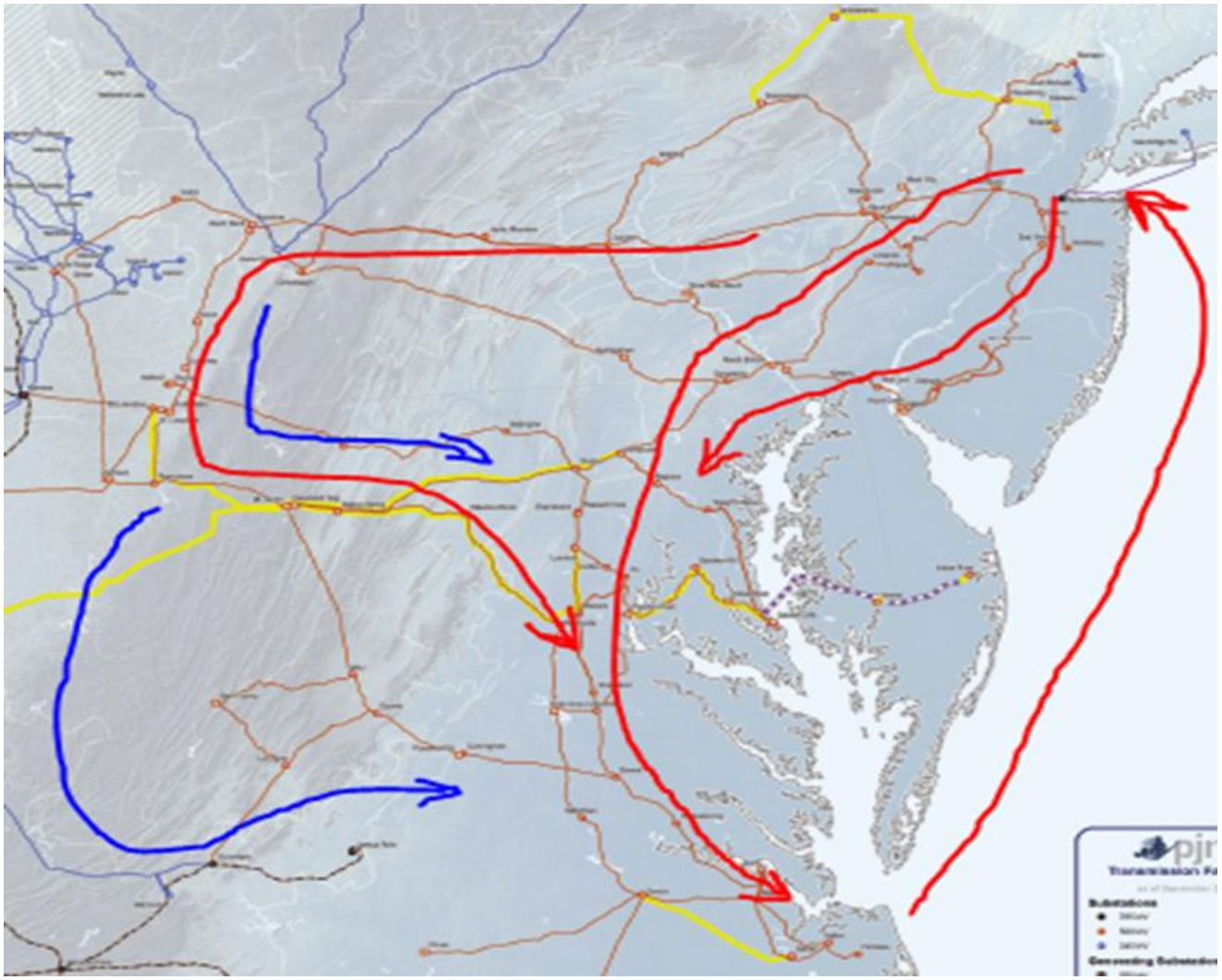
- We score well on 1 through 3:
  - Meet reliability needs
  - Substantial improvement of PJM's market efficiency
  - Outlook for the NJEL as a state-sponsored (PPR) project is strong
- PJM is working on adopting MD assessment & cost allocation rules in 2013
- Outlook for eligibility to Regional Facility classification is very promising

Siemens PTI Study of AWC Grid Reliability Benefits

- Studied 500+ possible contingencies on the PJM system by modeling AWC w/o offshore wind and effect of re-dispatch of 1000 MW of capacity south to north and north to south on those contingencies
- Findings:
  - AWC will:
    - Respond to numerous N-1-1 thermal contingencies
    - Helps with N-1-1 voltage violations
    - Enable heading off cascading for certain combinations of contingencies
  - AWC may require local upgrades
  - AWC represents a large-scale, long-term reliability enhancement.


Rough PJM 500 kV Power Flows (without AWC)
PA.
N.J.
MD.
DEL.
WEST VIRGINIA
VIRGINIA
SEE E. PENNSYLVANIA, MARYLAND, NEW JERSEY, N. DELAWARE DETAIL
SEE NEW YORK DETAIL
CHESAPEAKE BAY
LAKE ERIE
Atlantic Wind Connection

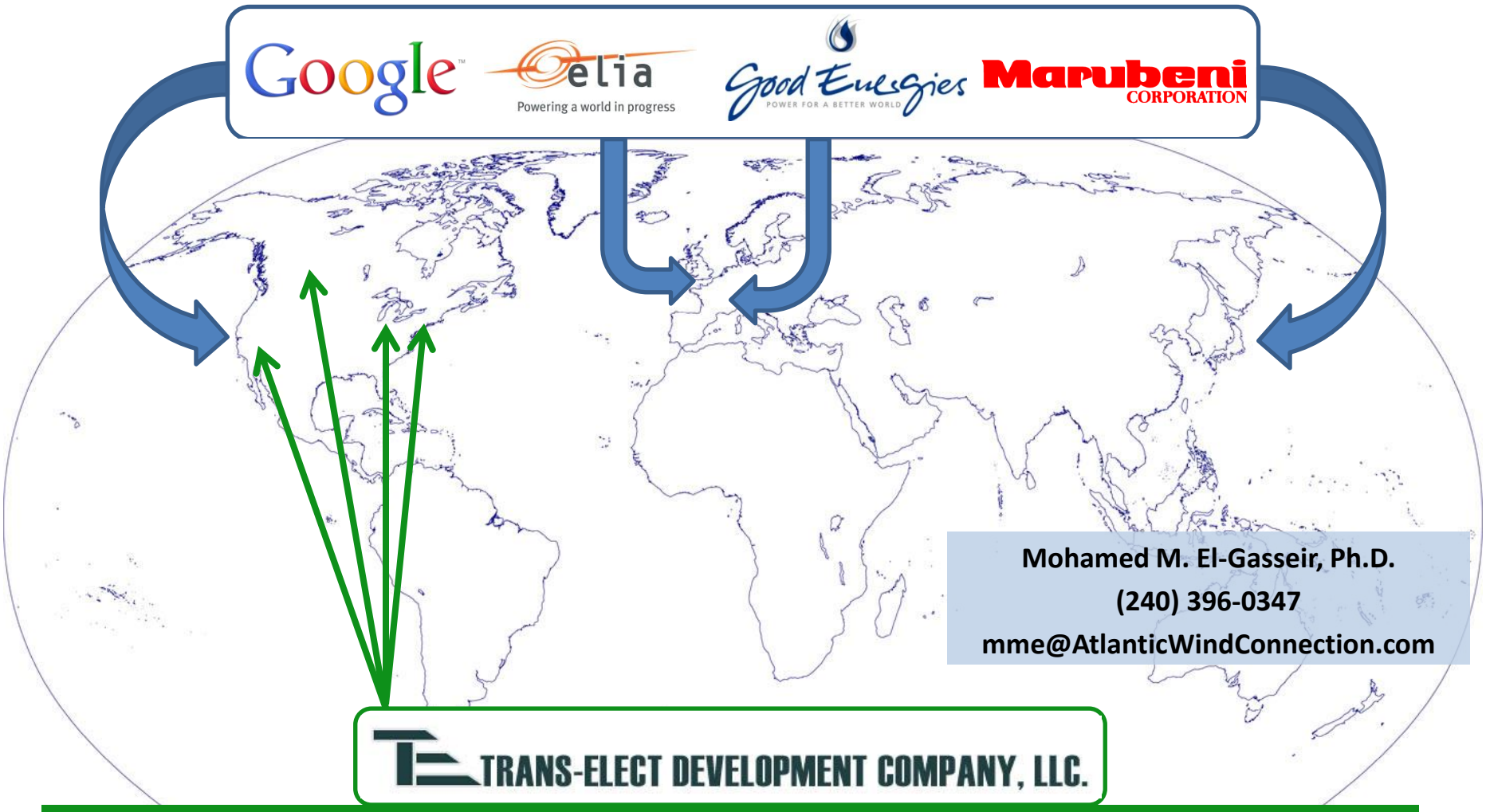
The AWC: A Generator of Counter-Flows Under Normal & Abnormal Conditions



Lessons Learned

- **The VSC/HVDC technology is very promising especially for areas served by mature HVAC systems**
- **The geographic scope is inter-zonal and inter-regional**
- **Working with the grid operator from the outset is essential**
- **FERC and grid operators should aggressively refine planning and cost allocation methods and procedures per Order 1000 directives to maximize the utility of VSC/HVDC transmission technology**
- **Federal and government agencies should take active interest in the development and implementation of VSC/HVDC backbones**

AWC is funded by a team of global investors



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Development Led by Experienced Independent Transmission Company