CIEMADeS
4th INTERNATIONAL CONFERENCE

(Case Study PR – USVI and possible expansion to BVI Interconnection)

May 6, 2011

Caribbean Basin Energy Grid as a U.S. Policy

Secretary of State of Puerto Rico Kenneth McClintock at the 33rd Miami Conference December 2009

"Interconnecting the electrical grids in the Caribbean Basin can make the generation of electricity from renewable energy more economically viable by creating a large scale transnational electricity market in which Caribbean countries could trade renewable energy rather than oil."

Caribbean Basin Energy Grid as a U.S. Policy

Secretary Clinton at the
Energy and Climate Ministerial
of the Americas
April 2010

"The OAS, the Caribbean energy ministers, CARICOM, the World Bank, the IDB, and officials from Puerto Rico and the U.S. Virgin Islands launched a dialogue to explore the possibility of installing undersea electric cables in the region to give the Caribbean access to new power supplies."

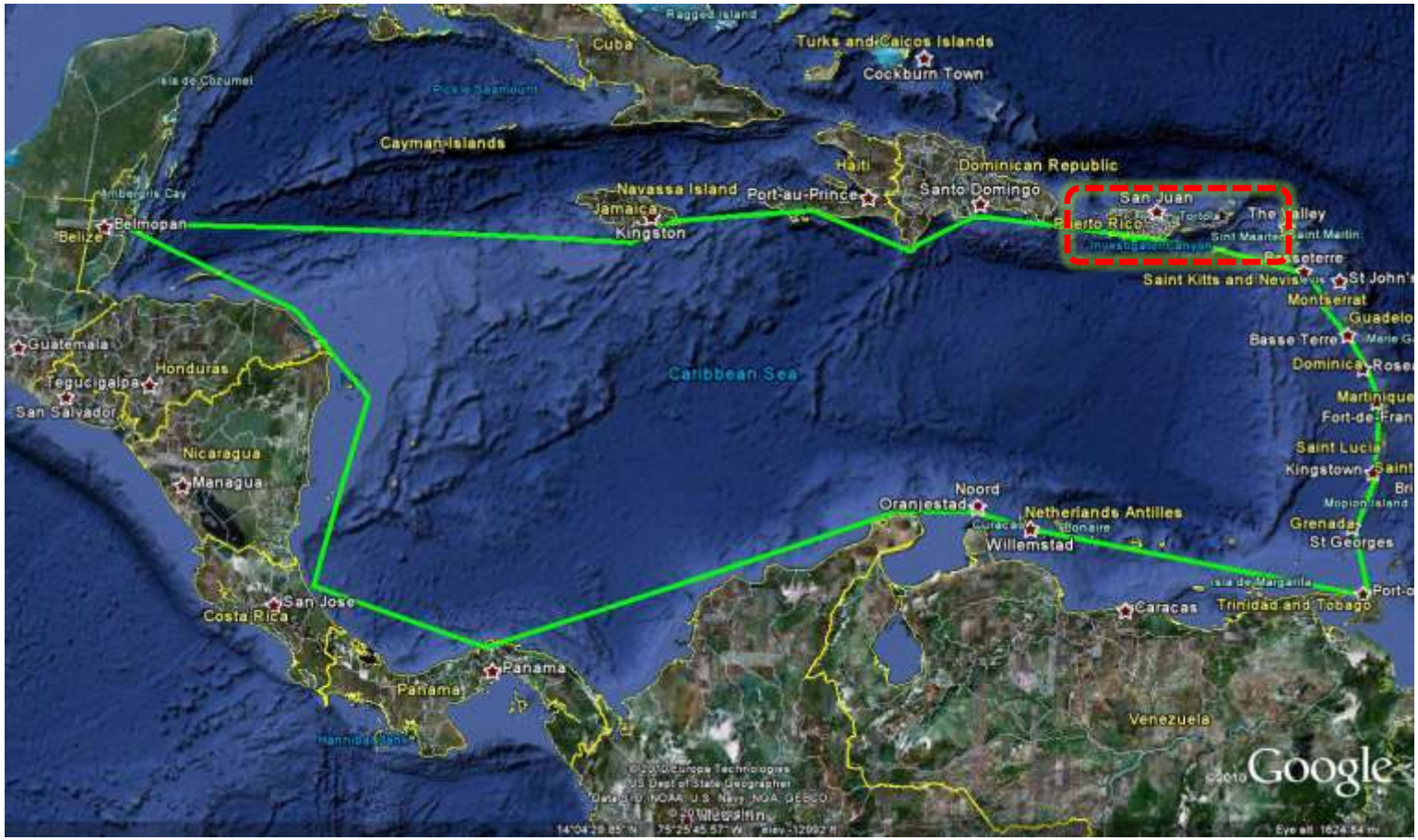
Caribbean Basin Energy Grid as a U.S. Policy

Secretary Chu at the Energy and Climate Ministerial of the Americas April 2010

"Some of these islands-states have wind and solar resources… in order to make them more economical it would be nice if you could connect these islands-states to each other… that would make the investment in clean energy renewables much accessible, more profitable"

Puerto Rico Proposal for the Caribbean Energy Grid

Connecting Puerto Rico – Dominican Republic – Haiti – Jamaica – Belize, Honduras – Costa Rica – Panama – Colombia – Curacao – Grenada – and other 14 Islands



Submarine Power & Telecom Cable From Puerto Rico to U.S. Virgin Islands

In 2009 the US Congress issued an e-mark requested by the USVI Delegate Donna Christensen and PR Resident Commissioner Pedro Pierluisi which allowed the a technical and economical feasibility study for the PR- UVSI electric interconnection project.

Proposed Project

1. VIWAPA authorized to pursue the feasibility in conjunction with Inter American Energy Sources LLC(IAES) to evaluate a project that considers the potential development of a 115 kV underwater transmission cable with fiber optics which will interconnect the two power grids.

2. Project will consist of approximately fifty miles (50) transmission cable with capacity of approx. 100-200 MW.

3. Anticipated cable route will initiate at the eastern point of Fajardo, Puerto Rico and terminate at Krum Bay, St. Thomas.

4. WAPA propose to purchase from IAES the renewable and no-renewable excess energy generated by PREPA , subject to terms and conditions of a power purchase agreement or other agreements deemed appropriate.

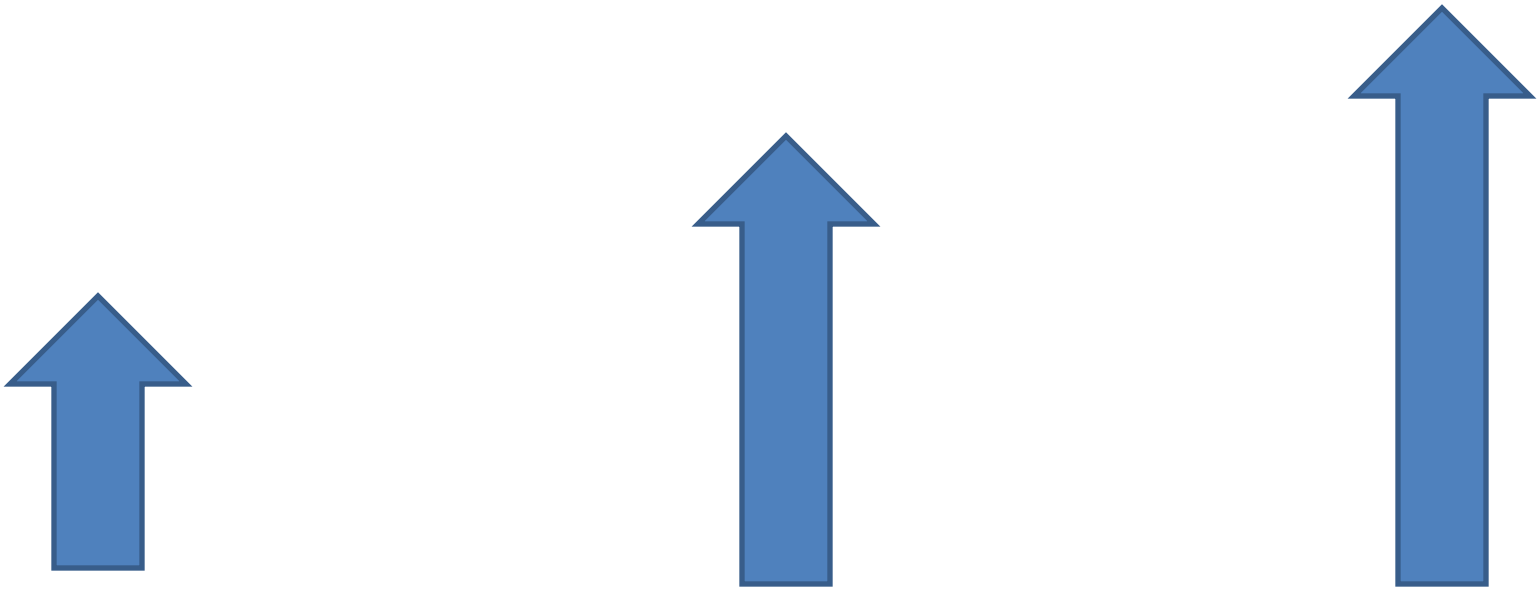
Why this Project is necessary?

1. Presently, St. Thomas has in service a power plant to provide electricity to St. Thomas, Saint John and Water Island. In case of a major incident such as; Tsunami, hurricane, earthquake or terrorist action, VIWAPA can loose the capacity of generating electric power for these three islands.

2. Presently VIWAPA power system is non-redundant due to the existing conditions of the power generators and the power demand on these three islands.

3. This project will allow VIWAPA to provide better maintenance to its existing power plant and to expand the desalinization process for water consumption.

Why this Project is necessary?



P.R.
$0.29

U.S.V.I.
$0.41

B.V.I.
$0.48

Federal Government Funding to the Project

1. Federal funds are necessary in order to reduce the financial impact of this project and facilitate environmental / technical studies.

2. Federal government assistance will significantly facilitate the project.

3. The cost of the kilowatt/hour to VIWAPA will be reduced.

4. This project will improve the economy of thousands of citizens of P.R., USVI, and the BVI .

5. Maximize the potential benefits of interconnecting neighboring within the Caribbean region.

Federal Government Funding to the Project (cont)

6. This interconnection serve as the initial phase in the development for the proposed project of the Caribbean Basin electrical power grid with readily available clean energy resources in the region .

7. Make available an alternate critical contingency measure to support the USVI power grid and its communication system to protect public health, safety, and overall intelligence, in the event of a natural or man-made disaster .

8. Reduce the cost of providing electricity to P.R., USVI and BVI. customers.

9. Decrease WAPA's 100% fossil fuels dependency which leaves WAPA vulnerable to high energy prices .

Benefits of the Project

1. **Lower electrical costs to P.R., USVI and BVI citizens.**

2. **Improved overall generation flexibility from a source with readily available excess energy .**

3. **Provide stability to the USVI and BVI electrical systems .**

4. **Potential for the development of new business opportunity via High Speed Broadband and communication technologies.**

5. **Hazard mitigation measure.**

Submarine Power & Telecom Cable From Puerto Rico to U.S. Virgin Islands

<u>IAES assumes all risks</u> for the construction, financing and operation of the project.

IAES is a not for profit company, totally owned by PREPA Holdings LLC, direct subsidiary of the Puerto Rico Electric Power Authority (PREPA).

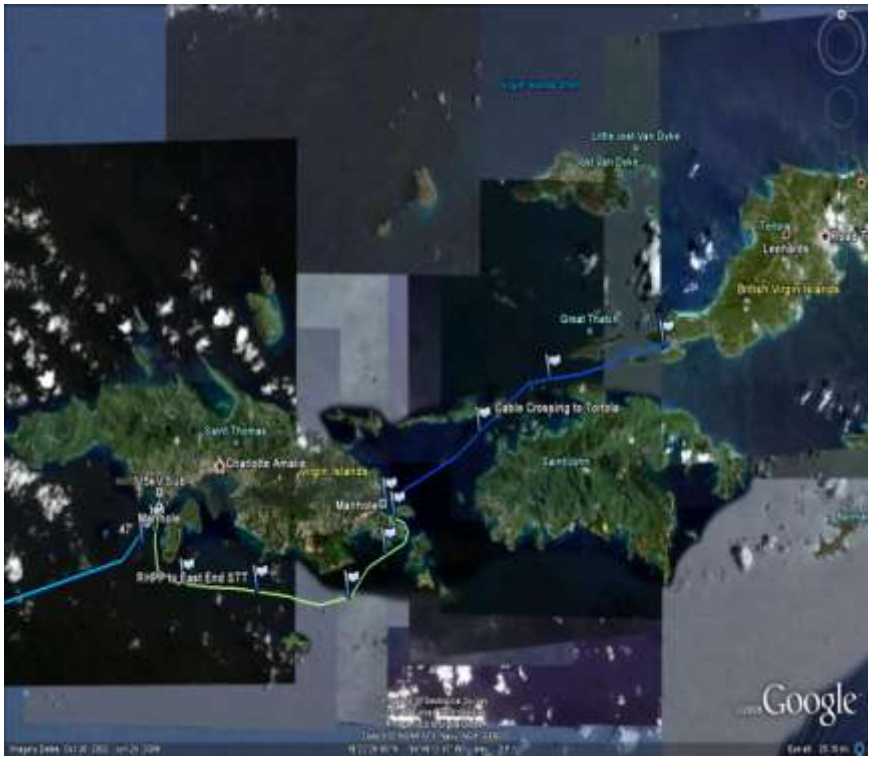
All net income developed by all IAES projects, will be transferred to PREPA for the reduction of the cost of fuel in the production of electric power for the people of Puerto Rico.

Submarine Power and Telecom Cable from P.R. to U.S.V.I.

- Route: Fajardo – St Thomas.
- Cable Length : 50 miles
- Initial Minimum Load: 20 MW @ 115 KV.
- Maximun Power Transfer of 200 MW
- An Interconnection with the Virgin Islands VIWAPA will allow IAES to sell PREPA's excess capacity to VIWAPA.

Submarine Power and Telecom Cable from U.S.V.I. to B.V.I.

- **Route 1: St Thomas-Harley Substation to St. Thomas-East End Substation (approximately 13 miles)**
- **Route 2: St. Thomas –East End Substation to Tortola (approximately 12 miles)**
- **Initial Minimum Load: 10 MW @ 34.5 KV.**
- **Maximum power transfer of 30 MW.**



Submarine Power and Telecom Cable from PR to USVI

Environmental Considerations

Submarine Cable from PR to USVI
Proposed Route

Marine Route Possible Impacts

- Navigable waters.
- Marine traffic during construction.
- Corals.
- Archaeological sites.
- Endangered plants and animals.
- Fisheries.
- Thalassia beds.

Take Off Location (Upland)

- Fajardo Switchyard .
- 1 mile from shoreline.
- No impact to turtle nesting grounds.
- Unlikely to impact archaeological sites. Site and surrounding areas are well developed.
- Cable will go underground from the switchyard to the shoreline following existing municipal road.

Shoreline Take Off Location

- No known turtle nesting grounds.
- Antillean Manatee present throughout the area.

Landing Location/ST Thomas Krum Bay

- VIWAPA Industrial site.
- No known sea turtle nesting grounds.
- No known archaeological sites .

Critical Habitat for Elkhorn and Staghorn Coral

Area 2: Puerto Rico and Associated Islands

Puerto Rico area, comprises approximately 1,383 square miles of marine habitat

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

Contact: Kim Amendola
727-551-5707

FOR IMMEDIATE RELEASE
Oct. 28, 2008

NOAA Issues Stronger Protections for Elkhorn and Staghorn Corals in Southeast United States

NOAA's Fisheries Service will increase its protection of threatened elkhorn and staghorn corals in Florida, Puerto Rico, and the U.S. Virgin Islands through a new rule to prohibit activities that result in death or harm to either species. The new regulations take effect on Nov. 21.

These corals provide the branching framework for reef creatures in search of a safe place to live, eat, and grow. The preservation and recovery of these threatened corals is essential to the conservation of an entire ecosystem. Both elkhorn and staghorn corals were listed as threatened under the Endangered Species Act in May 2006.

"These corals were once the major reef builders in Florida and the Caribbean, but now more than 90 percent of their populations are lost," said Roy Crabtree, NOAA's Fisheries Service's southeast regional administrator. "That not only threatens their survival-- it affects the entire ecosystem. This rule will strengthen our efforts to recover these corals by allowing us to address the human-induced threats affecting their status."

The rule will prohibit the import, export, take, and all commercial activities involving elkhorn and staghorn corals, including:

- collection or any activities that result in the corals' mortality or injury,
- anchoring, grounding a vessel, or dragging any other gear on the species;
- damaging the species' habitat;
- discharging any pollutant or contaminant that harms the species.

PUERTO RICO ELECTRIC POWER AUTHORITY · CORPORATE SEAL ·

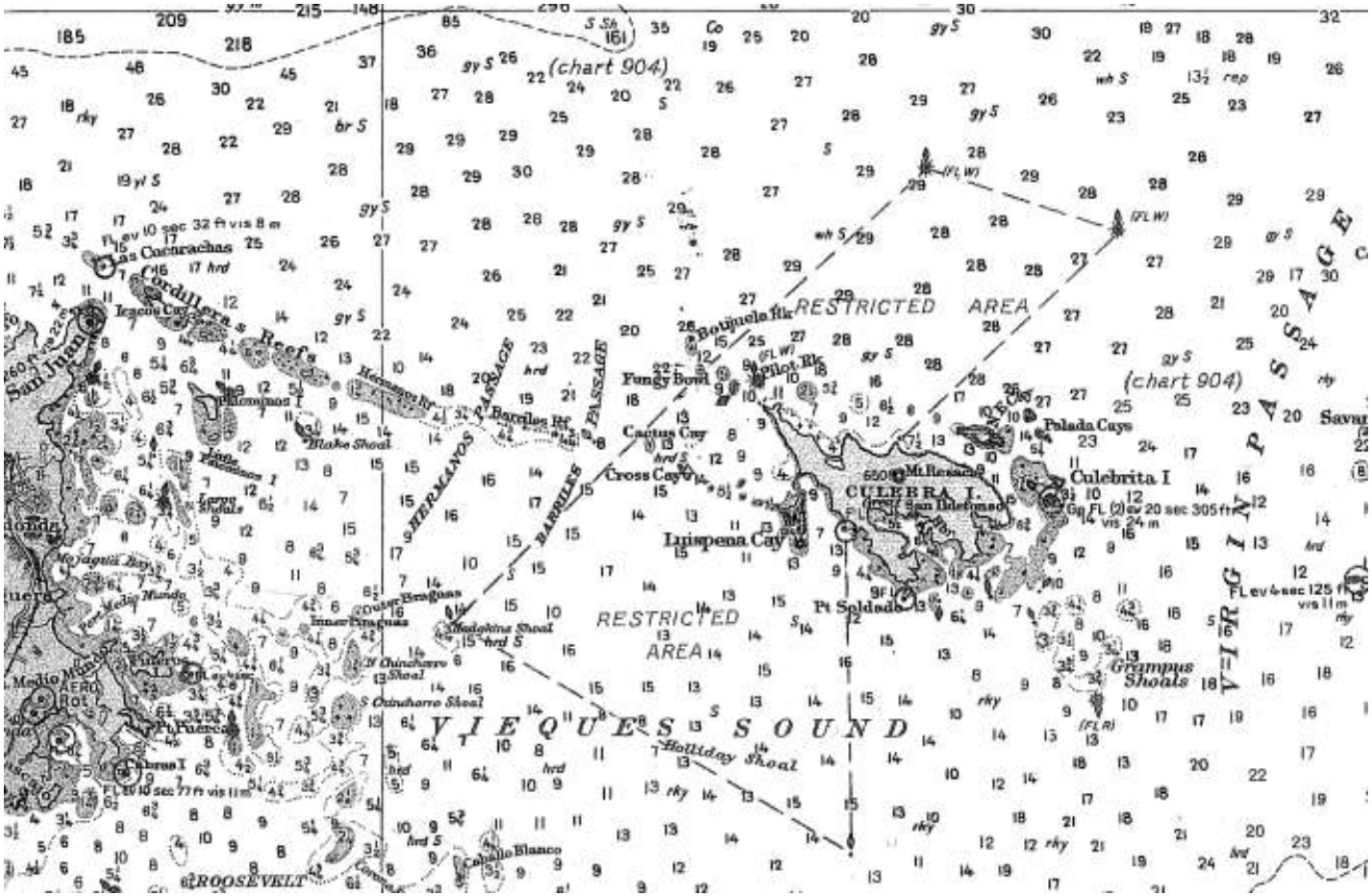
iaes InterAmerican Energy Sources LLC

VIRGIN ISLANDS WATER AND POWER AUTHORITY

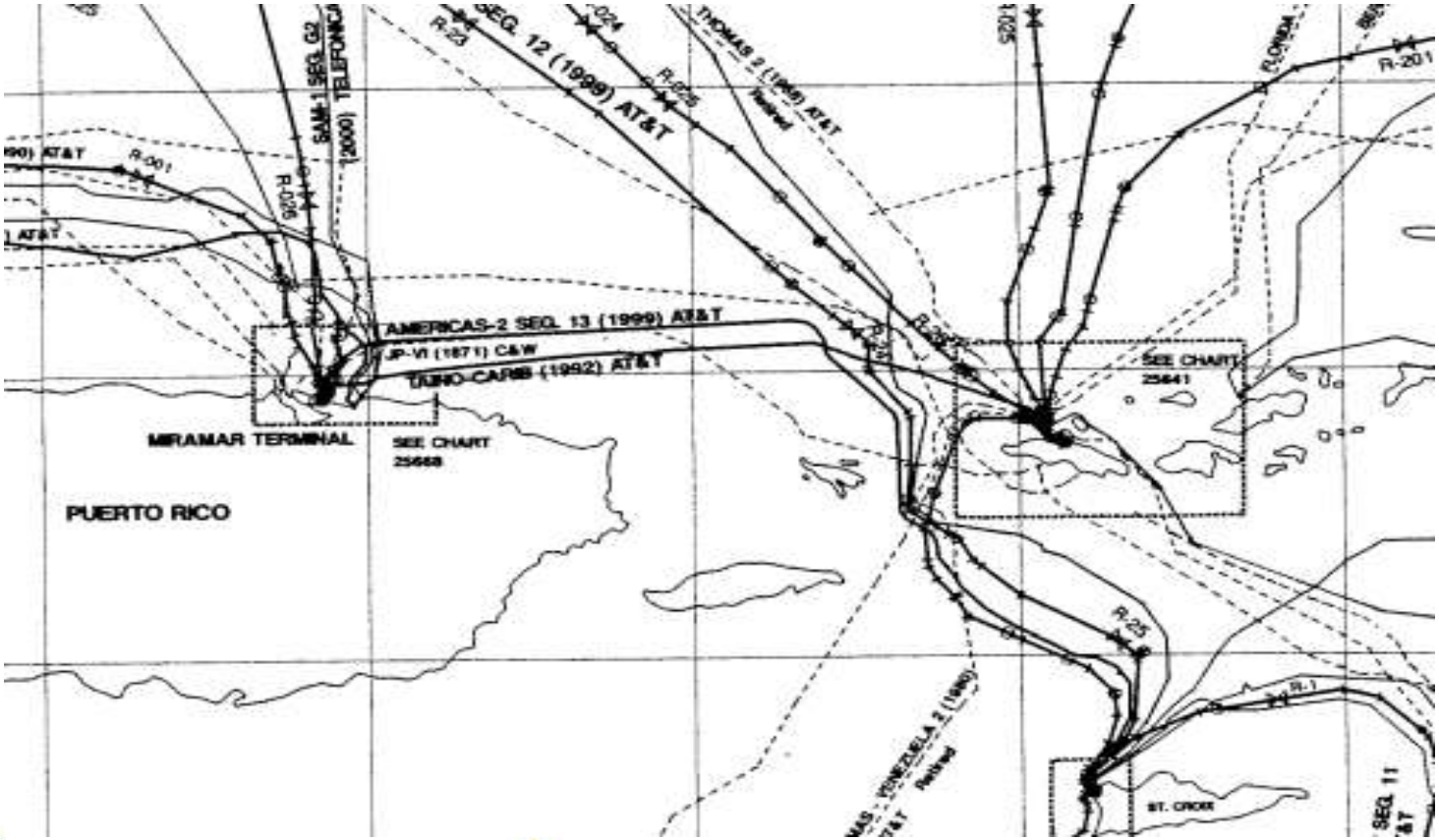
Desk Top Study
(Completed)

- Local weather conditions.
- General Bathymetry and morphologic conditions.
- Geology and sedimentology as it affects the sea floor along the proposed route.
- Locations of coral reefs.
- Fishing, dredging, shipping and other human activities.
- Identification of existing in use, abandoned or planned telecommunication cables, power cables, pipelines etc.
- Dump sites in use or abandoned.

Restricted Military Area



Presently Installed Submarine Telecommunication Cables



Permits/Consultations
ST Thomas

- Department of Planning and Natural Resources.
- Division of Coastal Zone Management.
- Division of Environmental Protection.
- Division of Fish and Wildlife.
- State Historic Preservation Office.
- Division of Comprehensive and Coastal Zone Planning.
- Coastal Zone Management, Major Water Permit.
- Water Quality Certificate.
- SHPO Endorsement.

Permits/ Consultations
Puerto Rico

- Environmental Impact Statement.
- Joint Permit Application.
- Individual Permit US Army Corps of Engineers.
- Coastal Zone Management Program Federal Consistency Certificate.
- Water Quality Certificate.
- Consolidated General Permit.
- Concession for the Use of Territorial Waters.
- Submerged Lands.
- Maritime Zone.
- Endorsement State Historic Preservation .
- Endorsement Institute of Puerto Rican Culture.

Permits/Consultations

- Endorsement Ports Authority.
- Consultation Section 7 Endangered Species Act.
- Consultation Essential Fish Habitat.
- Integrate Consultations (Essential Fish Habitat Consultation Guidance).
- Coral Reef Conservation Program.
- Endorsement Municipality of Fajardo.

Studies

- Bathymetry (sonar, magnetometry).
- Benthic Study (according to NOAA protocol).
- Identification of hard substrate as potential habitat, coral reefs, sea grass beds, essential fish habitat, other significant species and habitat type, Develop Biological Assessment, Potential impacts and mitigation measures, Develop monitoring plans.
- Archaeological investigation.
- Take off/Landing site survey.

Federal Agencies

- US Army Corps of Engineers.
- US Fish and Wildlife Service.
- National Marine Fisheries Service (National Oceanic and Atmospheric Administration, NOAA).
- Environmental Protection Agency.
- Department of the Navy.
- Coast Guard.

Pre-Construction Monitoring

- Sea turtle nesting activities shoreline take off and landing in Puerto Rico and St. Thomas.

- Monitoring will be performed according to regulatory agencies protocols

Monitoring During Construction

- Antillean Manatee (Marine Mammal Protecion Act).
- Standard Manatee Conditions for In-Water Work.

Post Construction Monitoring

- Assessment of Impact to Coral Communities.
- Mitigation for impact to living species.

Puerto Rico Electric Power Authority (PREPA)
Background

Puerto Rico Electric System

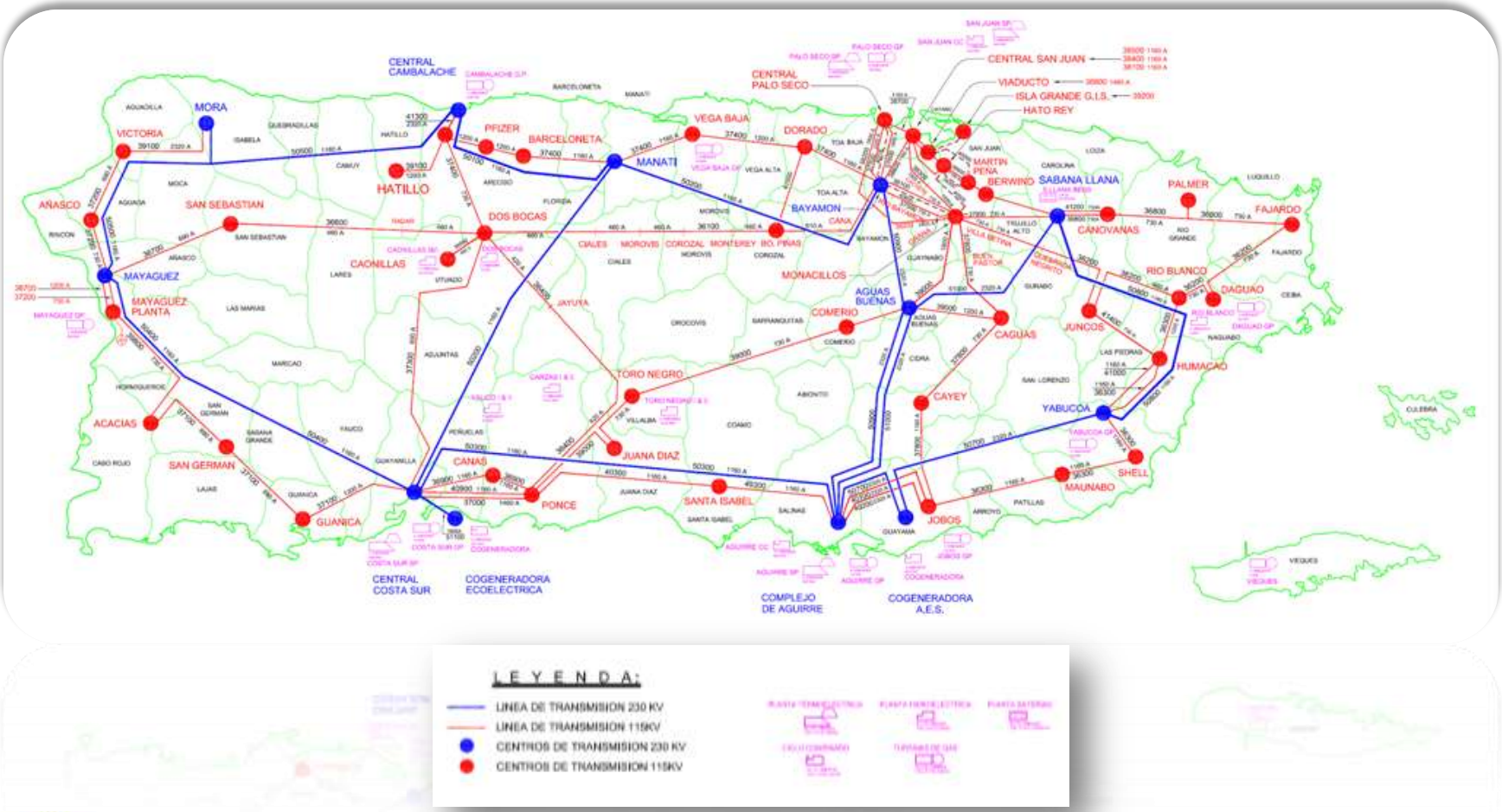
- **Our Transmission Grid**
  - 364.1 miles 230kV transmission
  - 710.2 miles 115kV transmission
  - 1,375.5 miles 38kV sub transmission
  - 54.7 miles Submarine Cable
  - 24.7 miles115kV underground

- Distribution Voltages Levels 13.2/8.32/7.2/4.16 kV
  - 31,446 miles overhead and underground

- 175 Transmission Centers, sectionalizers and substations at transmission voltage levels
- 342 Distribution Stations on Remote Control *

* Source: SCADA data base

Puerto Rico Electric System



LEYENDA:

- LINEA DE TRANSMISION 230 KV
- LINEA DE TRANSMISION 115KV
- CENTROS DE TRANSMISION 230 KV
- CENTROS DE TRANSMISION 115KV

iaes InterAmerican Energy Sources LLC

Puerto Rico Electric System

- **Historical Maximum Demand:** **3,685 MW (Sep 05)**
- **Maximum Demand for 2006:** **3,604 MW (Aug 06)**
- **Maximum Demand for 2007:** **3,546 MW (Aug 07)**
- **Maximum Demand for 2008:** **3,351 MW (Aug 08)**
- **Maximum Demand for 2009:** **3,404 MW (Aug 09)**
- **Maximum Demand for 2010:** **3,406 MW (Aug10)**

Puerto Rico Electric System

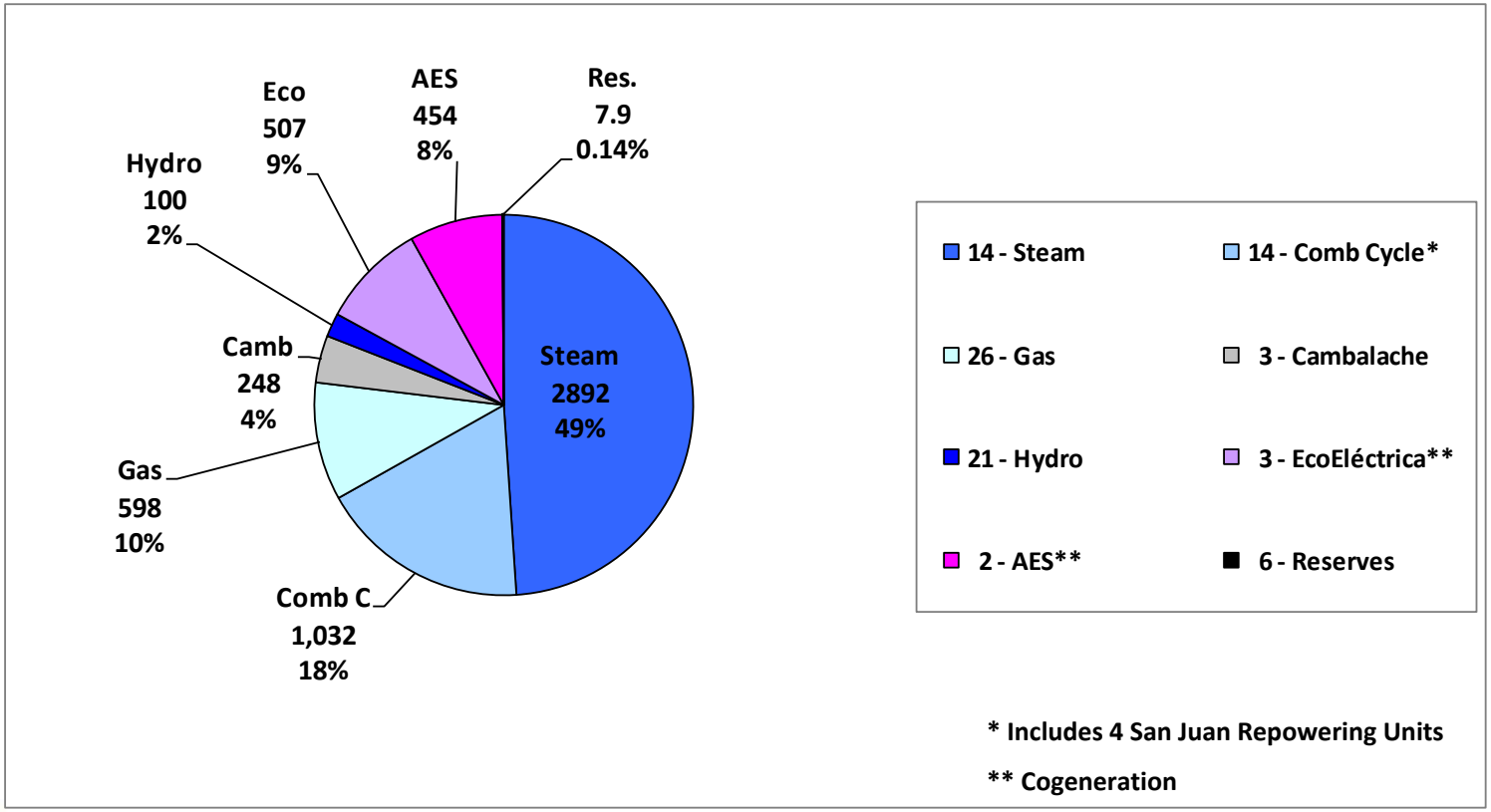
- **Load Concentration at North Area of Electric Network (70%), Highest Generation Capacity at South Area of the Island (70%).**

- **0.54% and 0.66% increase in Annual Maximum Energy Production and Maximum Load Demand (2000 – 2010).**

- **Load Factor: Annually 77.91%, Monthly 83.04, Daily 88.12% (Natural Year 2010; August, 2010; August 18, 2010).**

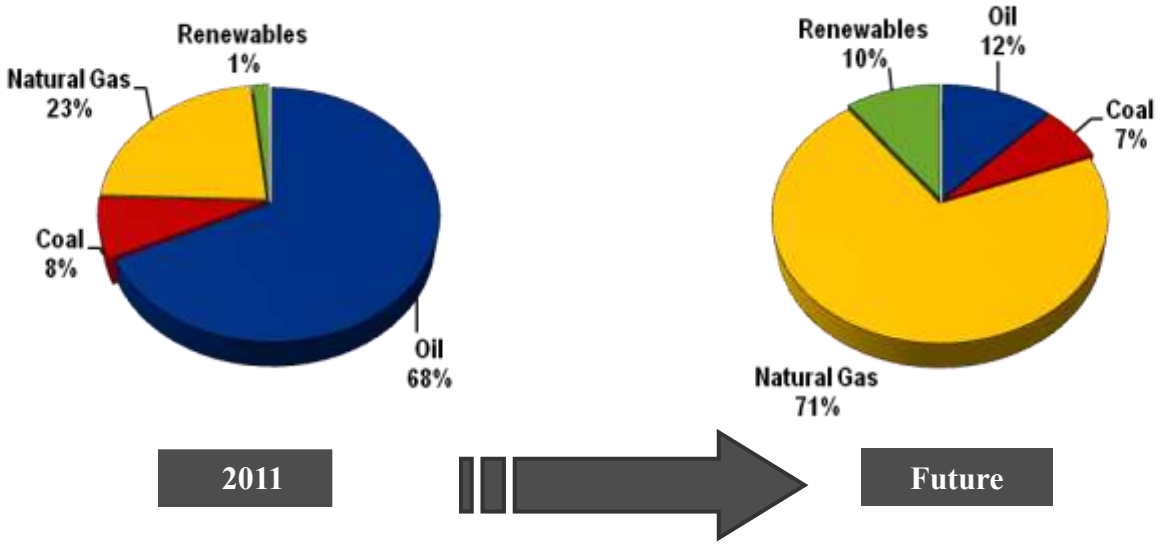
Puerto Rico Electric System

Installed Capacity 5,838.4 MW (4,877.1MW - PREPA)



Generation Objectives

Diversification of Fuel Sources – Installed Capacity



- **Reducing the fuel oil dependency is the way to go to reduce the energy price in Puerto Rico**
- **LNG and coal are intermediate phases in the way to the production of energy based on renewable energy sources**

PREPA's Strategic Goals – Integration of Renewable Energy Sources

- **Compliance with Existing Mandatory Renewable Portfolio Standards**
  - **Law 82 (Minimum Requirements).**
  - **12 % of the energy generation by 2015.**
  - **15 % of the energy generation by 2020.**

- **Maximize Penetration Levels of Renewables.**
  - **Integrate considerably higher penetration levels than mandatory Renewable Portfolio Standards.**
  - **Short term actions – more than 850 MW signed PPA's.**
  - **Medium term plan – integration of penetration levels of the order of 55 % of the peak demand.**

PREPA's Strategic Goals – Integration of Renewable Energy Sources (cont)

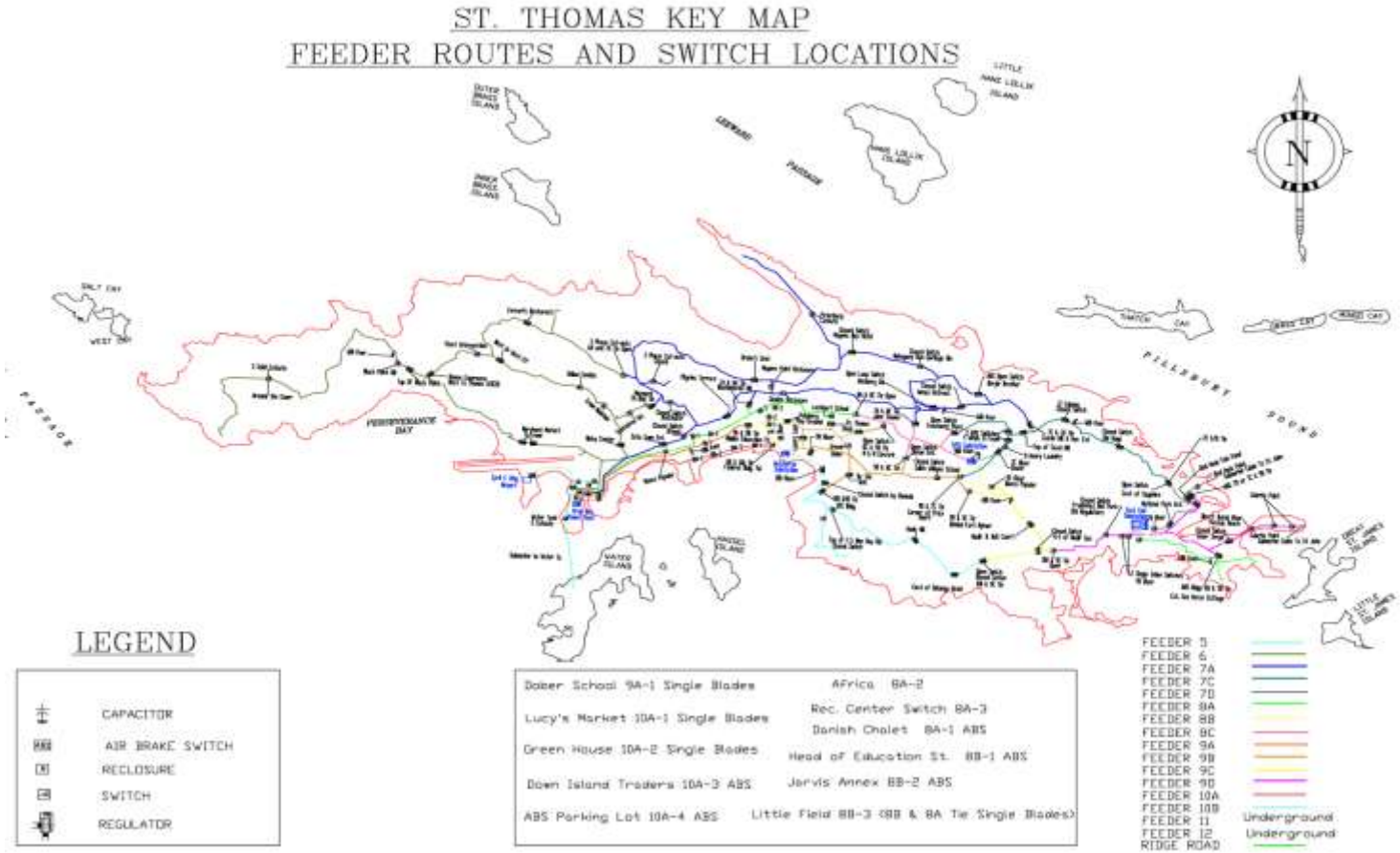
- **Grid Optimization Strategies**
  - **Additional Integration Studies to Accommodate High Penetration Levels.**
  - **Optimization of Regulating and Spinning Reserve Requirements and Frequency Control Algorithms.**
  - **Evaluation of Energy Storage Systems in Coordination with Demand Response Alternatives.**
  - **Optimization of Existing Frequency and Under-Voltage Load Shedding Schemes.**
  - **Integration of Cost Reduction (Natural Gas) and Cost Stabilization (Renewables) Strategies.**
  - **DC Links with External Neighboring Power Grids.**

Virgin Islands Water and Power Authority (VIWAPA)
Background

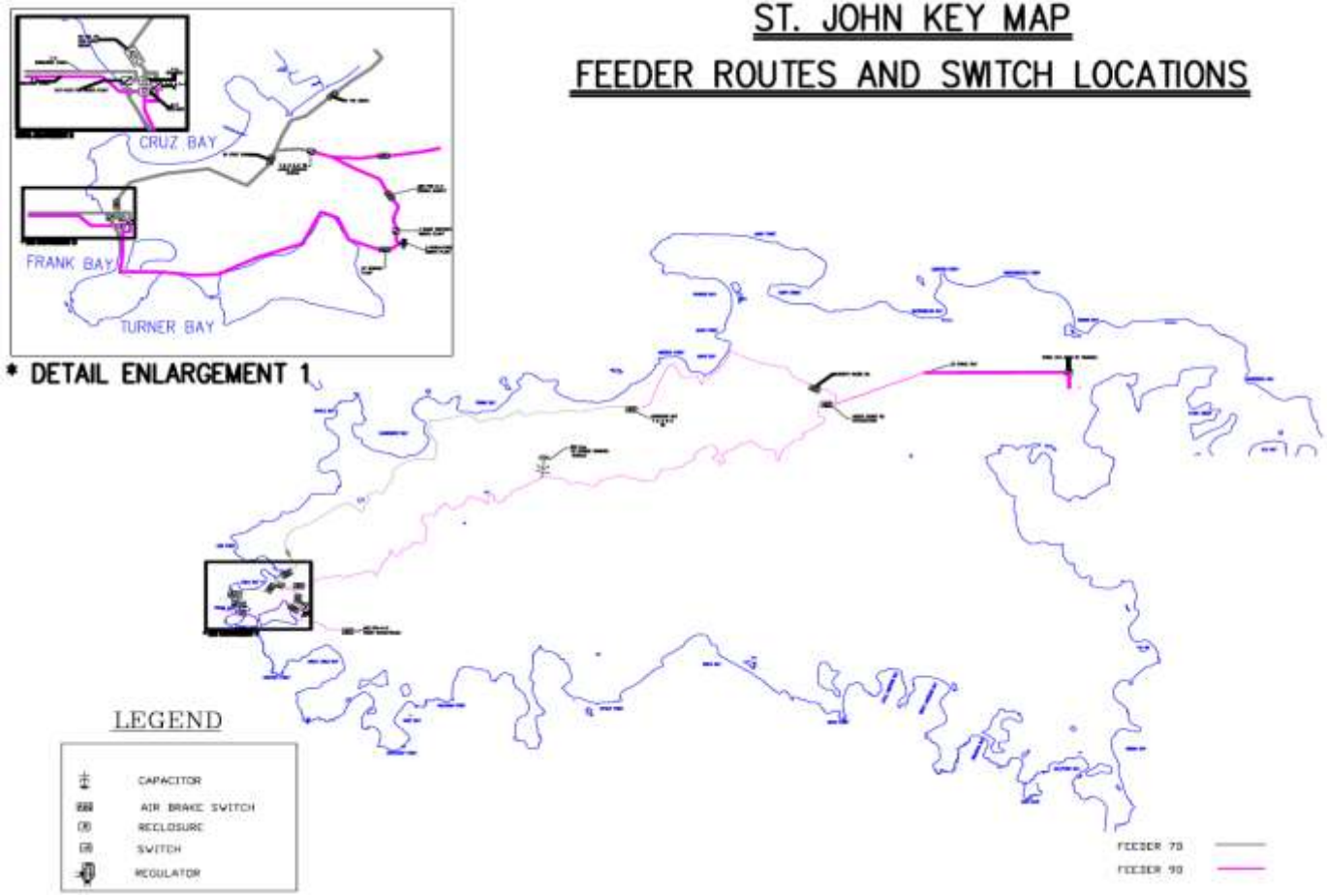
WAPA Generation – St. Thomas

St. Thomas / St. John - Randolph E. Harley Generating Station						
Ln. No.	Unit No.	Technology	Fuel Type	Rated Capacity		In Service Date
(a)	(b)	(c)	(d)	(e)		(f)
1	7 (St. John)	Reciprocating Engine Generator	No. 2 Oil	2.5		1985
2	11	Fired Boiler/STG [1]	No. 6 Oil	18.5		1968
3	12	Simple Cycle CTG	No. 2 Oil	12.5		1970
4	14	Simple Cycle CTG	No. 2 Oil	12.5		1972
5	13	Fired Boiler/STG [1]	No. 6 Oil	36.9		1973
6	15	Combined Cycle CTG/HRSG [1]	No. 2 Oil	20.9	[2]	1981
7	18	Combined Cycle CTG/HRSG [1]	No. 2 Oil	23.5	[2]	1993
8	22	Simple Cycle CTG	No. 2 Oil	24		2001
9	23	Simple Cycle CTG	No. 2 Oil	39.5		2004
10	Total			190.8		

Distribution on St. Thomas



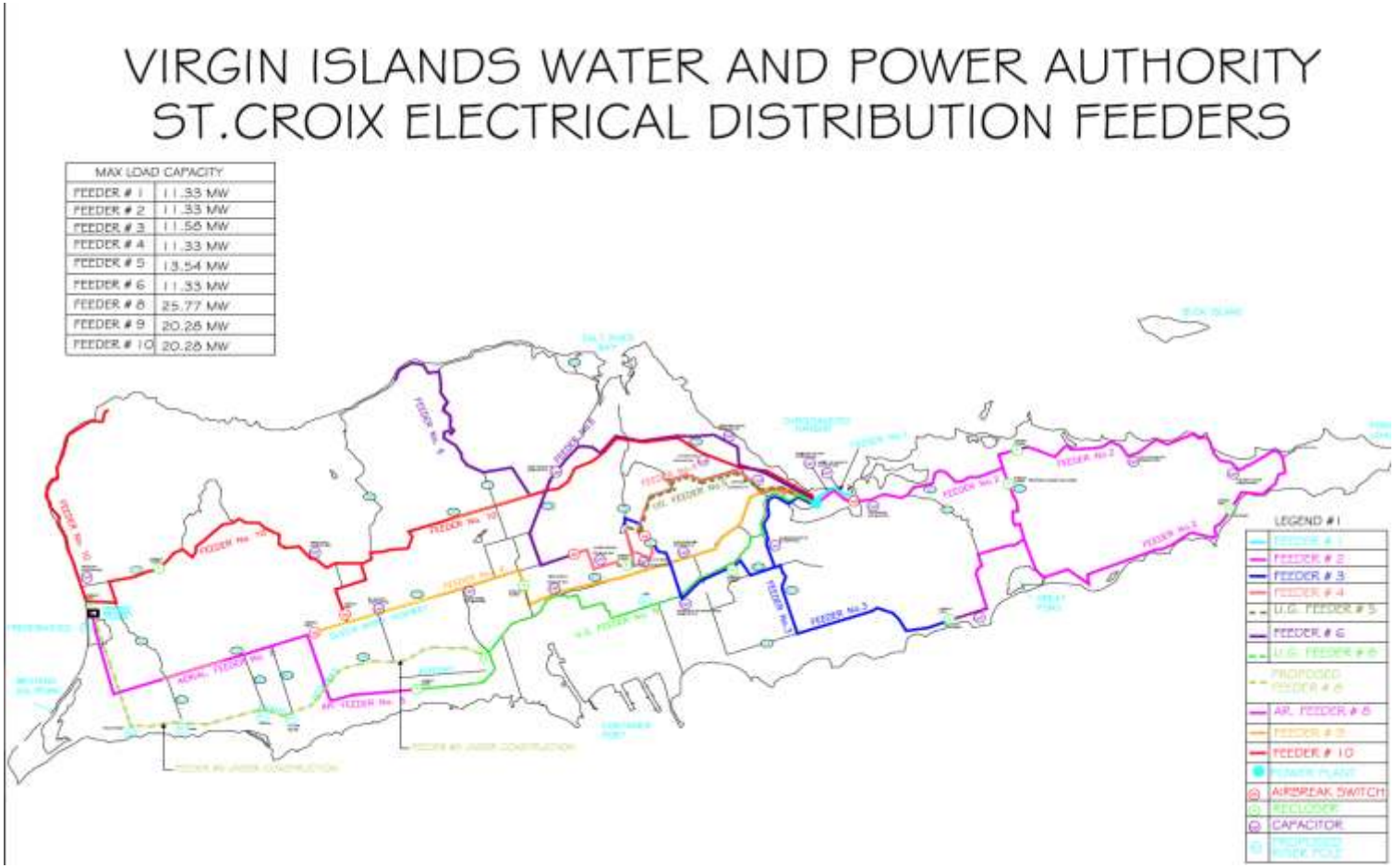
Distribution on St. John



WAPA Generation – St. Croix

St. Croix - Estate Richmond Generating Station						
Ln. No.	Unit No.	Technology	Fuel Type	Rated Capacity		In Service
11	10	Fired Boiler/STG [3]	No. 6 Oil	10		1967
12	11	Fired Boiler/STG [3]	No. 6 Oil	19.1		1970
13	16	Combined Cycle CTG/HRSG [3]	No. 2 Oil	20.9	[2]	1981
14	17	Combined Cycle CTG/HRSG [3]	No. 2 Oil	21.9	[2]	1988
15	19	Simple Cycle CTG	No. 2 Oil	22.5		1994
16	20	Simple Cycle CTG	No. 2 Oil	22.5		1994
17	Total			116.9		

Distribution on St. Croix



VIWAPA Background

1. Government-owned/public utility.
2. Primary source of potable water & power production in the Territory (U.S. Virgin Islands).
3. Major facilities located on St. Thomas and St. Croix.
4. Territorial Peak Power.
    1. St. Thomas/ St. John 45 MW min.– 88 MW max. (seasonal avg.).
    2. St. Croix 30 MW min.- 55 MW max. (seasonal avg.)
5. Power Generation Capability –(100 % fossil fuel dependent).
    1. St. Thomas/ St. John --198 MW.
    2. St. Croix --118 MW-

VIWAPA Background (cont)

6. Avg. cost of 34¢/kwh in Fiscal Year 2009
7. Water Production – Israel Desalination Engineering (IDE) & Reverse Osmosis Plants (RO)
    - Capacity
        - St. Thomas/ St. John-- 4.5 MGD.
        - St. Croix– 5.1 MGD
8. Total Number of Utility Customers:
    1. Water - 12,390
    2. Electric - 54,113

Siemens Interconnection Feasibility Study

Interim Report #1

Study Tasks

1. Kickoff Meeting & Data Gathering.
2. Draft Study Plan.
3. Submarine Cable Study.
4. HVDC Requirement Study.
5. Interim Report 1 & Technical Presentation.
6. Power System Studies.
7. Interim Report 2 & Technical Presentation.
8. Preliminary Cost Estimates.
9. Benefits Analyses.
10. Final Report.

Study Assumptions

Interconnection Parameters:

- **Puerto Rico – St. Thomas, 100 & 200 MW, 115 kV AC & +-150 kV DC, 50 miles.**
- **Krum Bay – Red Hook, St. Thomas, 50 MW, 34.5 or 69 kV AC, 20 miles.**
- **St. Thomas – BVI, 30 MW, 34.5 kV AC, 5 miles.**
- **St. Thomas – St. Croix, 100 & 200 MW, +-150 kV DC, 100 miles.**

System Sizes:

- **PREPA: 3500 MW peak load today.**
- **St. Thomas + St. John: 86 MW peak load today, 110 MW by 2025.**
- **St. Croix: 55 MW peak load today, 70 MW by 2025.**
- **BVI: estimated 25 MW peak load today, 32 MW by 2025.**

Study Preliminary Results

Interconnections Estimated Cost Summary

Interconnection No. & Cable Description	Delivered Power MW	Installed Cost MUSD
No.1: 115 kVAC 3/core: 3 x 1 x 500 mm2	100	
No.1: 115 kVAC single core: 1 x 800 mm2	200	
No.1: ± 80 kVDC single core: 1 x 500 mm2	100	
No.1: ± 150 kVDC single core: 1 x 500 mm2	200	
No.2A: 69 kVAC 3/core: 3 x 1 x 240 mm2	50	
No.2B: 69 kVAC 3/core: 3 x 1 x 240 mm2	50	
No.3: ± 80 kVDC single core: 1 x 300 mm2	80	

Interconnection Feasibility Study Objectives

- Review state-of-the-art technologies in HVDC transmission
- Recommend HVDC circuit configurations for the interconnections
- Identify reactive power requirements associated with HVDC interconnections
- Identify necessary AC/DC system enhancements associated with the interconnections
- Derive preliminary modeling parameters for the recommended HVDC systems for use in Power System Studies

Recommendations for Interconnections

- HVDC technology is suggested for:
  - Interconnection 1: Between Fajardo, Puerto Rico and Krum Bay, St. Thomas: 50 miles, 100 MW +-80 kV and 200 MW +-150 kV DC.
  - Interconnection 3: Between Krum Bay, St. Thomas and Christiansted, St. Croix: 100 to 220 miles, 100 MW +-80 kV DC.

- For Interconnection 2:
  - Between Krum Bay, St. Thomas and Red Hook, St. Thomas
  - Between Red Hook, St. Thomas and Tortola, BVI
  - Parameters are well within the range where AC alternative is feasible and less costly.
  - Use of AC will be reassessed, based on results of Power System Study.

Choice of HVDC Technology

- **Both PREPA-St. Thomas and St. Thomas-St. Croix Interconnections can be implemented with either conventional or Voltage Source Converter (VSC) HVDC technology.**

- **Taking into consideration the features of conventional and VSC DC technologies and specifics of cable design from the Submarine Cable Study, VSC technology is preferred.**

Why VSC HVDC?

Main advantages of VSC over conventional HVDC:

- **Low sensitivity of inverter terminal to characteristics of AC power system at the receiving end.**
- **VSC converters may operate at unity power factor.**
- **VSC converter may participate in voltage control of the AC power system to which it is connected.**
- **HVDC with VSC can deliver power to isolated loads with no local generation.**
- **HVDC with VSC can be used for black start of an islanded AC power system.**
- **HVDC with VSC do not have the problem of DC current return encountered with conventional DC systems, which makes it more advantageous in terms of environmental concerns.**

Preliminary Cost Results

Table 10-1. Comparison of HVAC and HVDC Systems, Including VSC Estimates, for the Puerto Rico - St. Thomas Interconnection

Item No. & Description	Route km / no. of cables	Delivered Power MW	Installed Cost M USD
1. 115 kVAC 3/core: 3 x 1 x 500 mm2	80 / 1	100	
2. 115 kVAC single core: 1 x 800 mm2	80 / 3	200	
3. ± 80 kVDC single core: 1 x 500 mm2	80 / 2	100	
4. ± 150 kVDC single core: 1 x 500 mm2	80 / 2	200	

The cost data in Table 10-1 show clearly that, when the cost of VSC converters is taken into account, there is, given that the costs are budgetary only, very little difference between the HVAC and HVDC system options.

A final selection of the optimum technology for this Interconnection can only be made once the merits and disadvantages of each technology have been evaluated during the system studies.

Conclusions

- **VSC HVDC technology is suggested for the following two interconnections:**

  - **Interconnection 1: Between Fajardo, Puerto Rico and Krum Bay, St. Thomas, 100 or 200 MW.**
  - **Interconnection 3: Between Krum Bay, St. Thomas and Christiansted, St. Croix,100 MW.**

- **Preliminary parameters have been prepared for use in power flow and dynamic simulation analyses.**

- **Reactive power requirements for the proposed HVDC systems and necessary upgrades to the interconnecting AC power systems will be determined in the Power System Studies Task.**

Siemens Interconnection Feasibility Study

Interim Report #2

Study Tasks

- 1. Kickoff Meeting & Data Gathering.
- 2. Draft Study Plan.
- 3. Submarine Cable Study.
- 4. HVDC Requirement Study.
- 5. Interim Report 1 & Technical Presentation.
- 6. Power System Studies.
- 7. Interim Report 2 & Technical Presentation.
- 8. Preliminary Cost Estimates.
- 9. Benefits Analyses.
- 10. Final Report.

SIEMENS

2010 Approximate System Sizes

PREPA
Peak load: 3,354 MW
Installed capacity: 5,831 MW

St. Thomas/St. John
Peak load: 88 MW
Installed capacity: 167.7 MW

St. Croix
Peak load: 55 MW
Installed capacity: 122.6 MW

BVI
Peak load: 33 MW
Installed capacity: 46.6 MW

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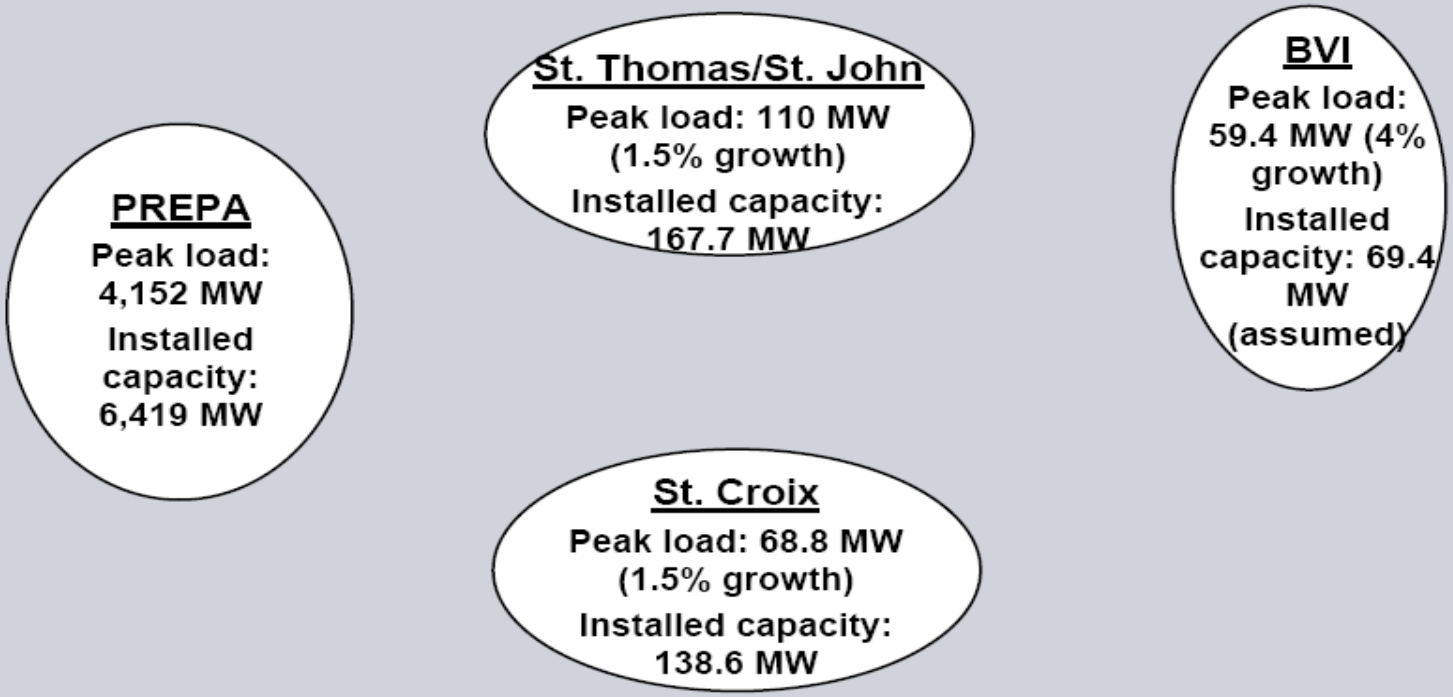
2025 Approximate System Sizes



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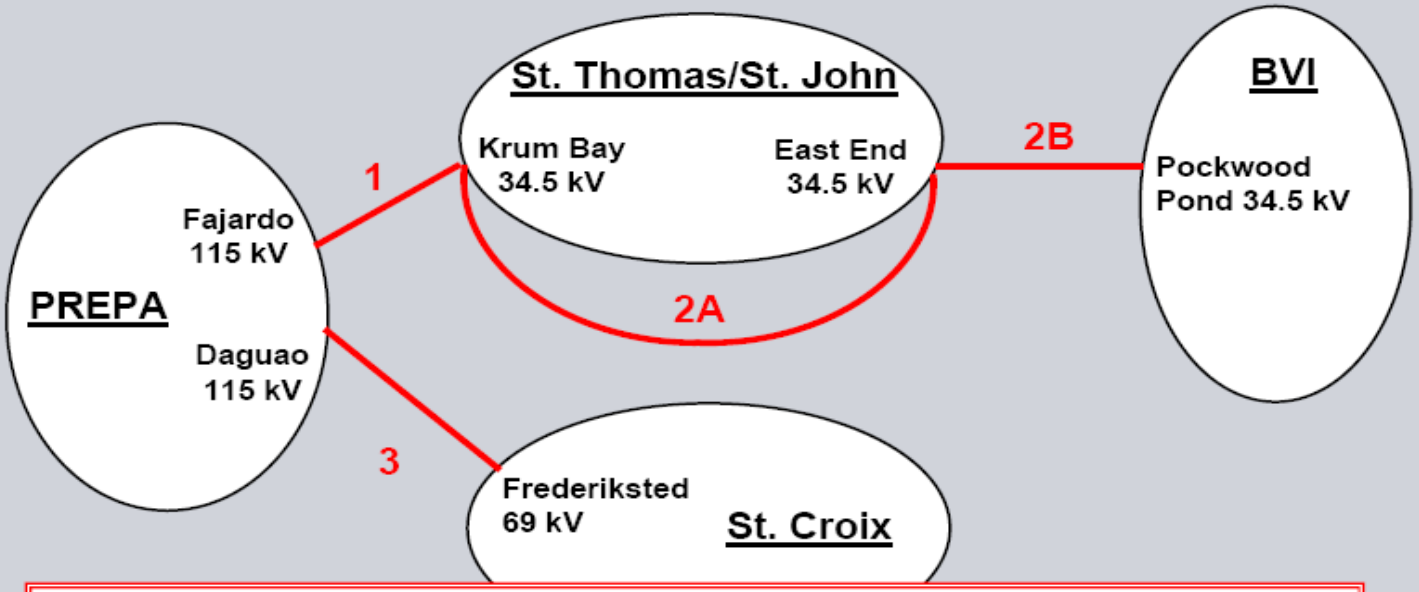
Interconnections Studied



1. Puerto Rico – St. Thomas, 100 or 200 MW, 115 kV AC, ±80 or ±150 kV DC
2A. Krum Bay – East End, St. Thomas, 50 MW, 69 kV AC
2B. St. Thomas – BVI, 50 MW, 69 kV AC
3. Puerto Rico – St. Croix, 100 MW, ±80 kV DC

Power System Study Criteria

- **Thermal study: Normal (pre-contingency) and post- contingency (N-1) branch flows compared with facility normal ratings or emergency ratings.**

- **Voltage study: Bus voltages maintained within 95% and 105% of nominal during normal and post-contingency.**

- **Stability study: Stability during simulation of 3-phase-to- ground faults and generator outage faults in St. Thomas & St. Croix systems and at interconnection points in PREPA.**

- **Short circuit study (only in St. Thomas & St. Croix): Fault currents calculated with all generators modeled in service and compared with breaker duties provided.**

Conclusions

- Power system study results show that some upgrades will be needed in the USVI, PREPA and BVI systems.
- In St. Thomas:
  - Use two 69/34.5 kV transformers at Krum Bay.
  - Trip Interconnection 2B whenever interconnection 2A is outaged.
  - Add frequency control function to DC system for the interconnection with PREPA.
- In St. Croix:
  - Upgrade Midland-Richmond 69 kV Circuit, Frederiksted-Richmond 69 kV Circuit and Frederiksted-Midland 69 kV Circuit.
  - Add 40 Mvar of shunt capacitors at Richmond 15 kV bus.
- DC system for interconnection with PREPA needs frequency control capability.

Conclusions

- **In PREPA:**

  Post-contingency overloads of some 115 kV circuits and associated low voltages near the points of interconnection being reviewed by PREPA.

- **In BVI**

  System will require upgrade if load growth is expected to stay at 4% per year through 2025.

  Shunt compensation will be required if significant number of generators are turned offline to accommodate power import.

  Underfrequency load shedding system will need to be coordinated with that of St. Thomas, if the islands are interconnected.

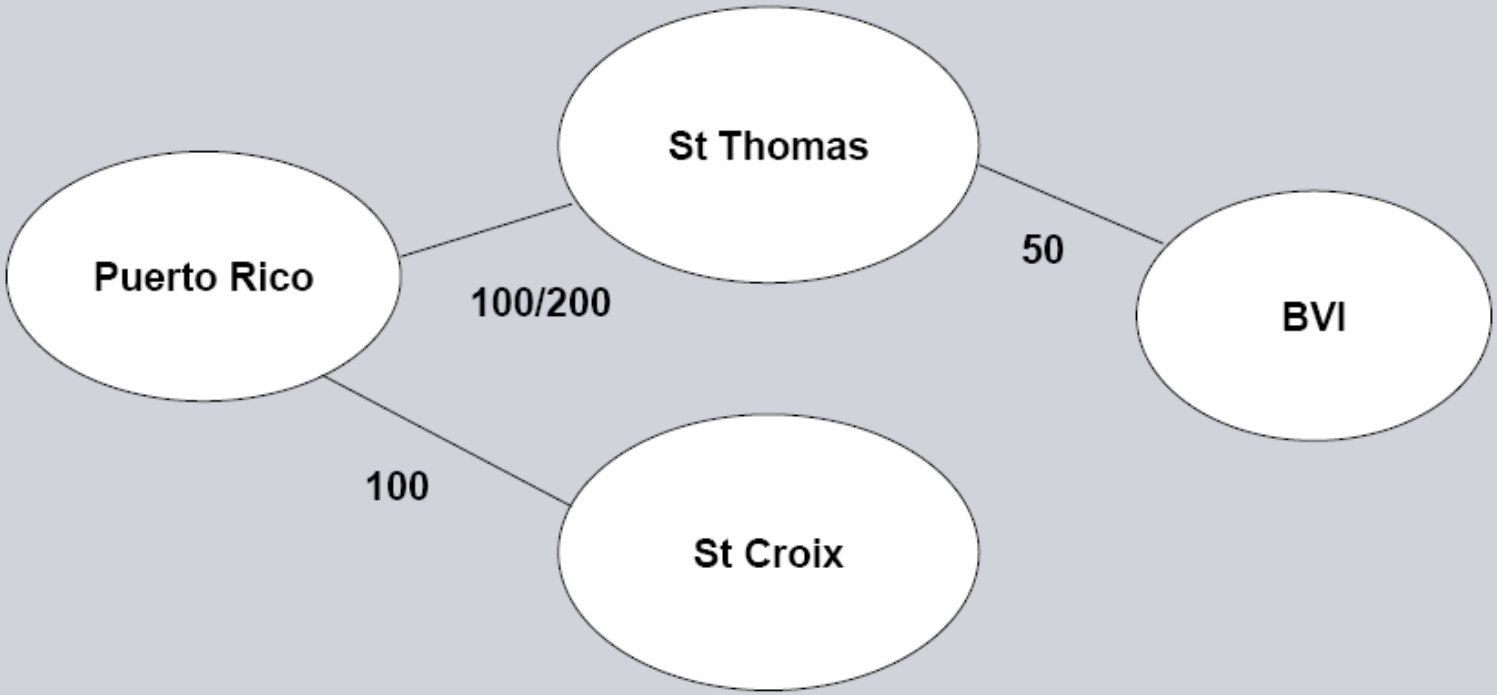
- **Severe disturbances, such as 3-phase faults, may cause instability problems.**

Upcoming Tasks

- Results from 400 MW Puerto Rico – St. Croix submarine cable design.
- Revise Interim Report #1.
- Continue to gather data for benefits study.
- Task 8 Cost Estimate Study.
- Task 9 Benefits Study.
- Task 10 Draft and Final Reports.

SIEMENS

Model for Economic Study



Questions?