Transitioning Island Utilities To a High Renewable Energy Supply

A BRIGHTER ECONOMIC FUTURE THROUGH CLEANER ENERGY

The Island Energy Innovations Team

Chris Elliott
Chief Executive Officer

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Commercial Real Estate developer and entrepreneur since the early 80's, Chris Elliott is currently the lead developer and serves as Vice President of Planning of William & Punch, LLC. Mr. Elliott is currently developing the 600-acre, $575 million mixed-use mega beach resort in the Caribbean with 4 and 5 Star hotels on site. Understanding the importance of reducing carbon emissions and minimizing power consumption, this state-of-the art development plans to integrate renewable technologies such as wind, solar, and pumped hydro-electric storage.

Mr. Elliott has been involved with renewable energy since 1978 when he perfected an "envelope" passive solar home design that both heats and cools comfortably without any electrical assistance or back up heating system.

Mr. Elliott majored in Mechanical Engineering and Physics at Georgia Tech 1968-1971.

The Island Energy Innovations Team

Paul Chakroff

Director of Environment & Natural Resources

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In 13 years on St. Croix Paul Chakroff has served as director of the Eastern Caribbean Program of The Nature Conservancy (TNC) and executive director of St. Croix Environmental Association (SEA). He is currently a consultant in environmental conservation and renewable resource management. Since 2009 Mr. Chakroff's primary focus has been on energy, including assessment of environmental and public health impacts of fossil fuel combustion, and development of renewable energy solutions for the U.S. Virgin Islands. As executive director of SEA, he concentrated on assessment of waste-to-energy and biofuel energy. As a partner in Island Energy Innovations, LLC and Solar Delivered, LLC, Mr. Chakroff has focused on wind, solar, and bulk energy storage.

Before moving to St. Croix Mr. Chakroff worked in environmental science and natural resources management in Africa, Asia, the Caribbean, the Middle East and the USA with a Washington, D.C. based consulting firm. He worked for the US Environmental Protection Agency on environmental assessment of energy technologies, including Ocean Thermal Energy Conversion (OTEC) and off-shore natural gas development. As a Peace Corps Volunteer with the Philippine National Pollution Control Commission, he conducted research on environmental impacts of an oil-fired power plant serving Manila, Philippines.

Mr. Chakroff holds an MS degree in water resources management and BS degree in forest biology from Syracuse University and the State University of New York (SUNY) College of Environmental Science and Forestry.

The Island Energy Innovations Team

Steve Garner, P.E., C.E.M.
Director of Engineering & Technology

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Owner and chief engineer of Tropitech Solutions, a U.S. Virgin Islands based company providing electrical engineering consultation, renewable energy solutions, and industrial and commercial energy assessments. Mr. Garner has recently become a managing partner in Solar Delivered LLC., an 8-year old company with over 500 installed Solar PV and Solar Hot Water systems.

Steve has over 23 years of system design, industrial automation, engineering, product, and technology development experience. In 2008, he served as Vice-President of Engineering & Technology at Quality Electric Supply for 5 years. While there, he guided the company's vision in strategic areas of technology and research, engineering, and project operations. Renewable Energy, power quality, and industrial control technologies were primary initiatives.

Mr. Garner worked for Eaton Corporation as a Project Manager and Engineer for over twelve (12) years where he designed and managed over $315 million of industrial automation projects. Steve holds a Bachelor of Science degree in Electrical Engineering from the University of Alabama at Birmingham (1988) and is a registered Professional Engineer in the U.S. Virgin Islands. He obtained his Certified Energy Manager (CEM) certification in 2013. Mr. Garner is an active member of the Institute of Electronic and Electrical Engineers (IEEE), the Association of Energy Engineers (AEE), and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

WHO WE ARE …

- **Independent developer** of renewable energy and bulk energy storage solutions
- Based in the **U.S. Virgin Islands**
- Focused on energy solutions for the **Caribbean Region**
- IEI principals have extensive background in **business, engineering, and environmental review**
- **Partner** with leading development, engineering, infrastructure supply firms, and regional governments

Strategic Alliances

- **USVI Partner & Project Sponsor**
  - Water & Power Authority, V.I. Energy Office, USVI Economic Development Authority, U.S.V.I. Government

- **Gridflex Energy, LLC.**
  - Experts in feasibility and permitting of large-scale energy storage projects, focusing on pumped hydro storage systems and integration.

- **Homer Energy, LLC.**
  - HOMER Energy provides grid and energy system modelling as well as consultation on renewable energy for utilities, governments, and technology developers. Homer was a natural choice based upon their work through the National Renewable Energy Laboratory (NREL) during the USVI Energy Development in Island Nations (EDIN) initiative.

WHAT WE DO …

- Utility Scale Renewable Energy Integration **Consultant**
- Provide **Concept Design**
- Provide Pre and Site-Specific **Feasibility Studies**
- Identify **Financial Assistance**
- Provide "**Shovel Ready**" Projects for Developers

THE CHALLENGE

- **High Energy Rates and Dependence on Fossil Fuels**
  - Island communities face unique challenges due to traditionally few options for base load energy and economies of scale.
  - **Bottom Line: High Energy Rates have led to a poor economy. Dependence on non-island resources greatly affects our energy security.**
  - *"As is the case with many island utilities, VIWAPA faces several particular challenges when planning for its future energy needs. A generation system which is being converted to LPG in addition to diesel fuel and potentially natural gas, increasing amounts of intermittent solar powered electricity, low load growth and other issues have fueled the need for a long term resource plan" --- WAPA RFP for IRP*

- **USVI has moved aggressively with Renewable Energy**
  - 32 MW Solar PV and 7 MW Biomass
  - Reached our Renewable Energy Aggregate ("Cap") very quickly.

USVI Renewable Energy Timeline

July 2009	➢ Act 7075 signed into Law. Reduce fossil fuel dependence by 60% no later than 2025.
Nov 2010	➢ MOU Signed between USVI and DOI to establish the USVI EDIN pilot project. DOE Support, including NREL
Nov 2010	➢ EDIN Working Groups Established
April 2011	➢ VIPA installs **450 kW** Solar PV at CEKA
June 2011	➢ Inter-Island Connectivity Feasibility Study between PR, USVI, and BVI Completed
June 2013	➢ WAPA approves agreement with Tibbar for **7 MW** Biogas
July 2013	➢ WAPA signs agreement with Vito to supply propane

USVI Renewable Energy Timeline

Jan 2014	➢ VIEO & NREL Complete Utility Scale Wind Study
Sep 2014	➢ WAPA awards Integrated Resource Plan development
Oct 2014	➢ IEI completes and releases "A Renewable Energy + Storage Base Pre-Feasibility Report for the U.S. Virgin Islands"
Oct 2014	➢ **4MW** WAPA Solar PV completed in St. Croix (Estate Spanish Town)
Jan 2015	➢ WAPA signs agreement for **6 MW** of Solar PV with St. Croix Solar
Feb 2015	➢ **4.2MW** WAPA Solar PV completed in St. Thomas (Estate Donoe)

MOVING FORWARD

- To move forward, we needed to completely evaluate our system in order to provide a complete integrated solution to continue our transformation.
- The territory needed a detailed Integrated Resource Plan (IRP). Initial phase of Plan is to be released in a couple of months.
- IEI was developing a Pre-Feasibility Study for the U.S. Virgin Islands prior to the release of the IRP Request for Proposal.

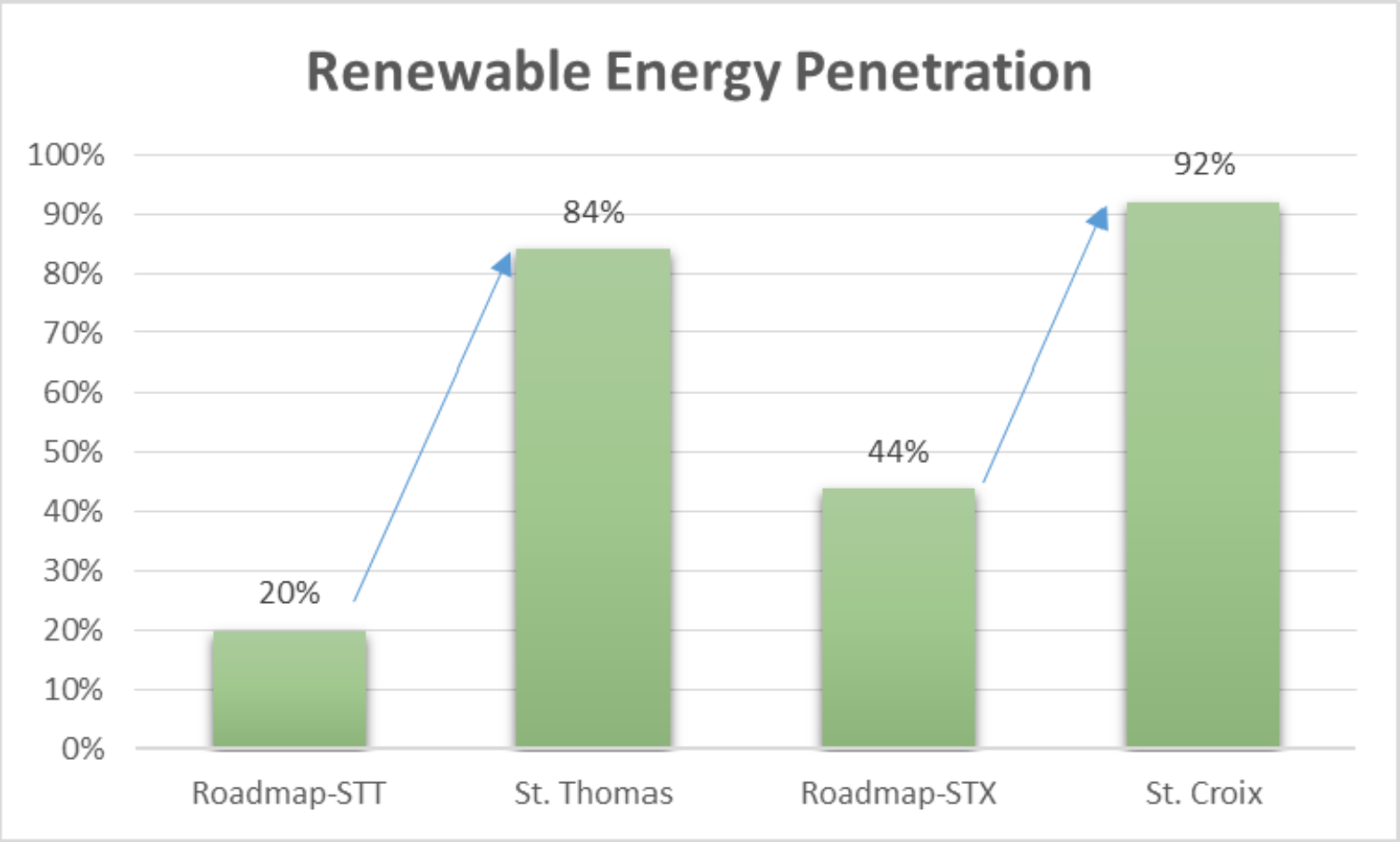
  A Renewable Energy + Storage Base for the United States Virgin Islands Pre-Feasibility Report

- The IRP is an important step in the energy future of the USVI. The USVI Pre-Feasibility Study can be used to support, verify, and improve the Integrated Resource Plan.

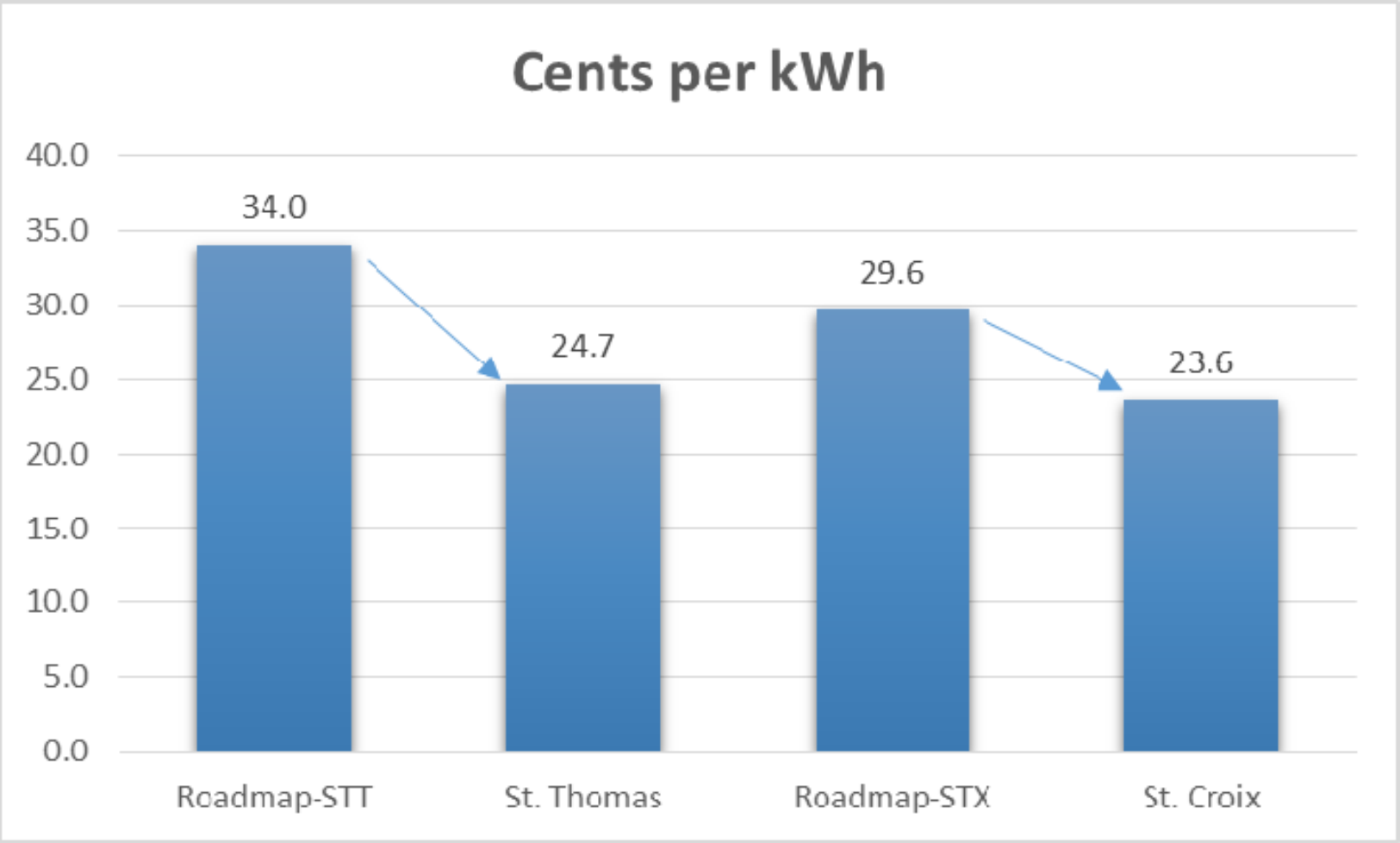
NEXT STEPS

- Evaluate, Modify, and Act upon the results of the IRP
- Begin site-specific site studies.
  - Approximate Cost $600,000 for USVI.
  - The EDA has listed the Study as a Comprehensive Economic Development Strategy (CEDS) project for 2015.
- This presentation will discuss a summary of our findings and discuss why we should move forward with these studies.

PRE-FEASIBILITY STUDY SUMMARY



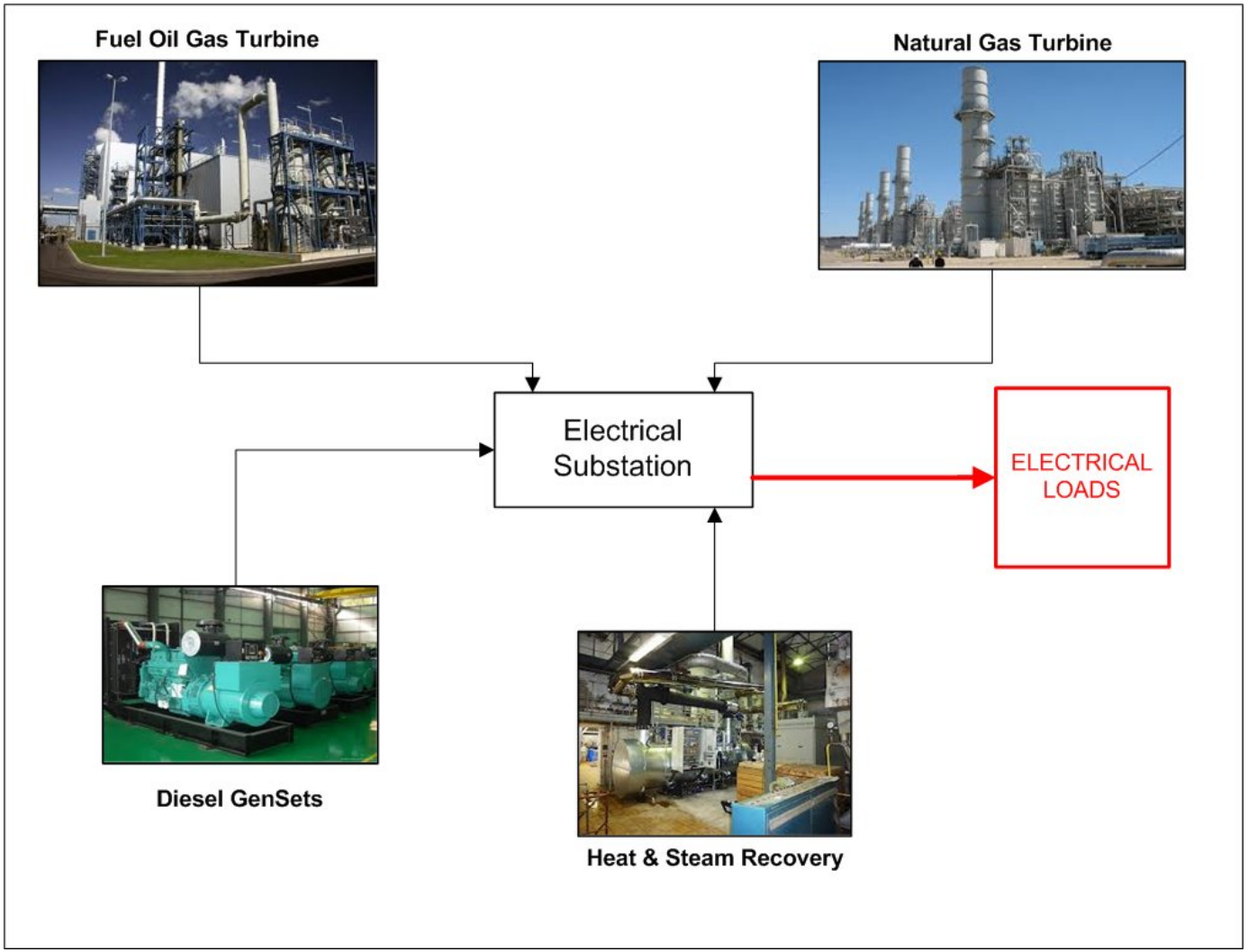
PRE-FEASIBILITY SUMMARY



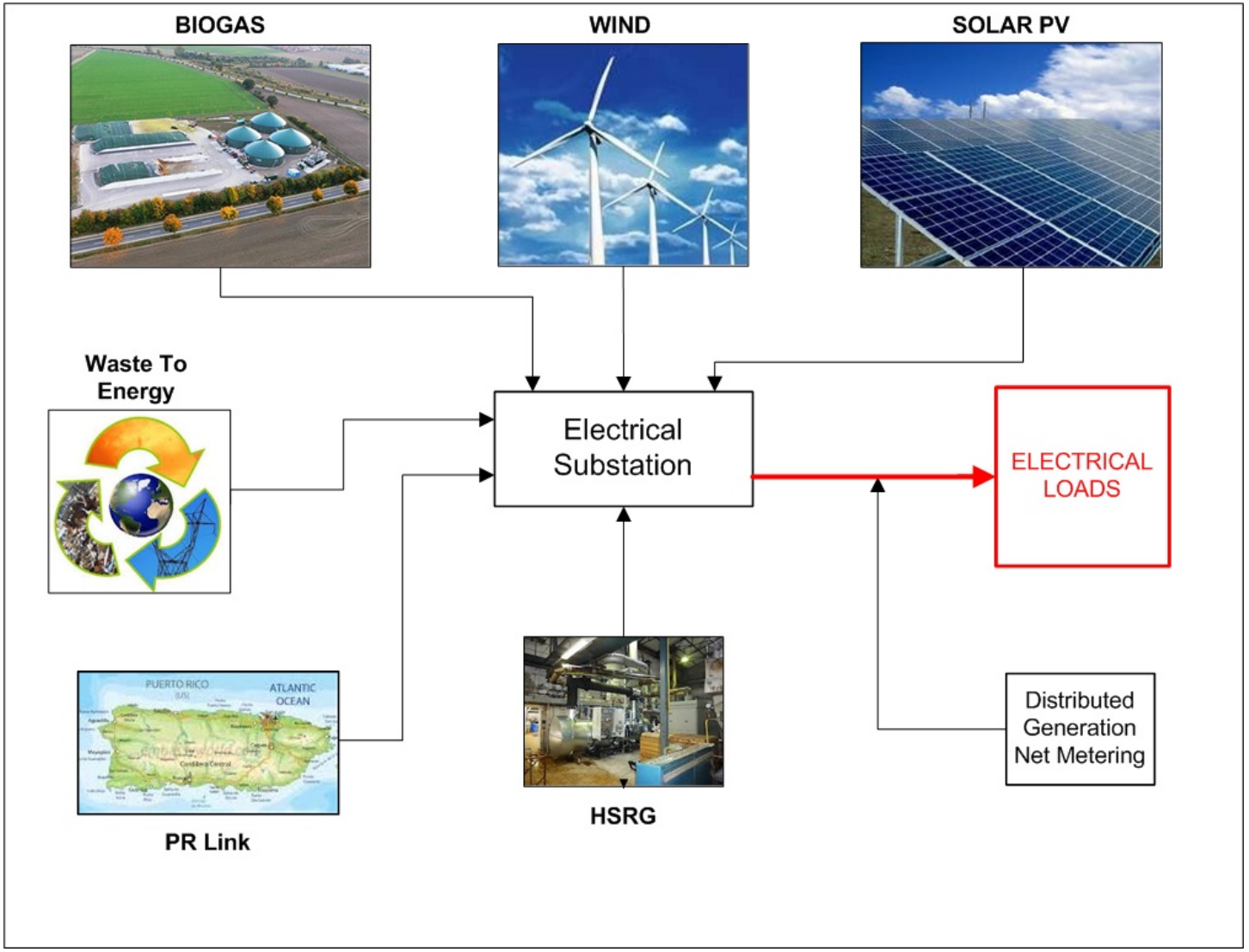
Overview

- ***Integrated energy solution*** taking advantage of the islands' natural assets as well as existing and future baseload generation
  - Wind, Sun, and Water
  - Biomass, Waste-to-Energy, Geothermal, Fossil Fuel
- ***Challenges*** of Renewable Energy Generation
- ***Solving*** the challenges
- Existing ***Implementations***
- A look at proposed USVI ***energy portfolio***
- ***Benefit & Cost*** Considerations

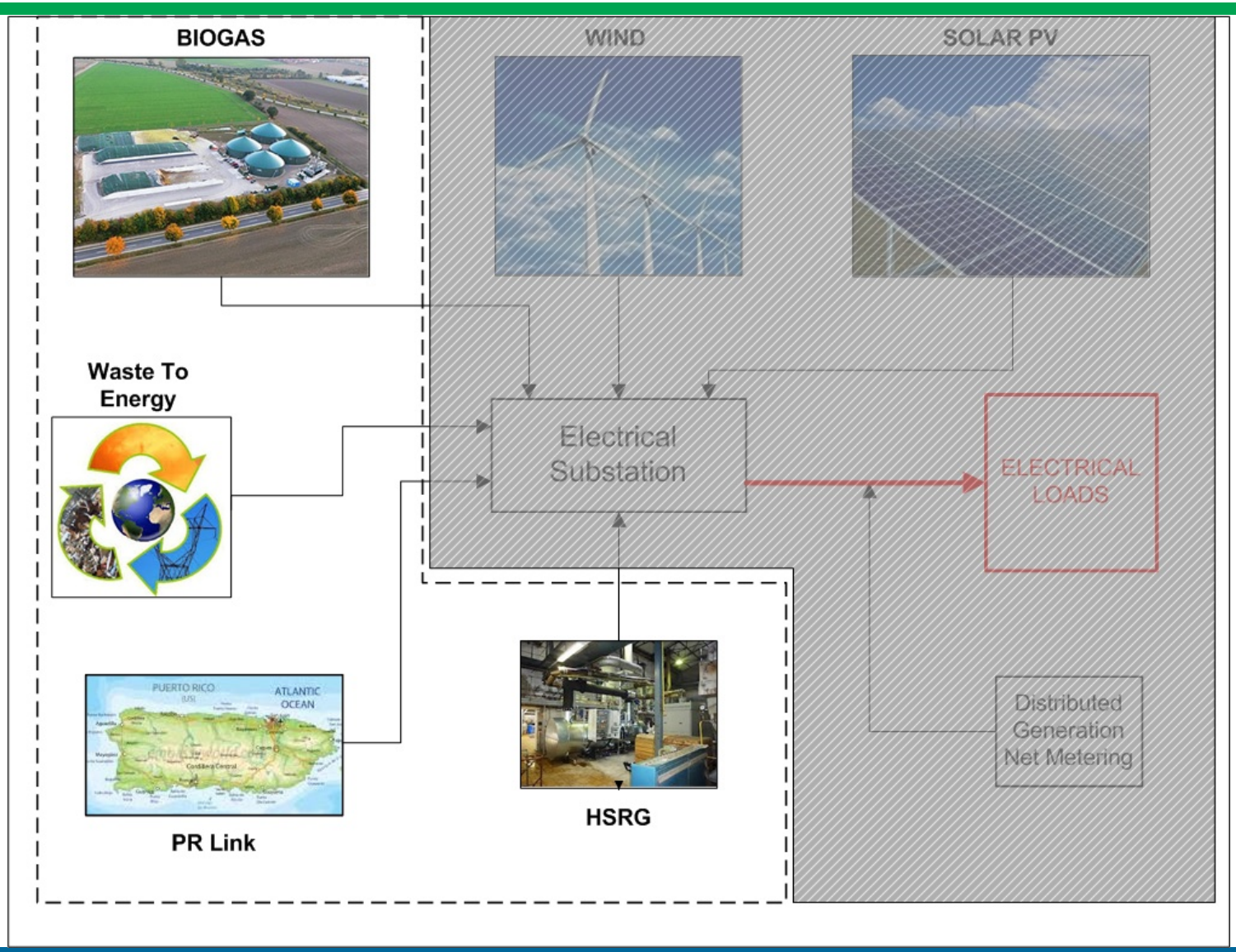
Fossil Fuel Generation



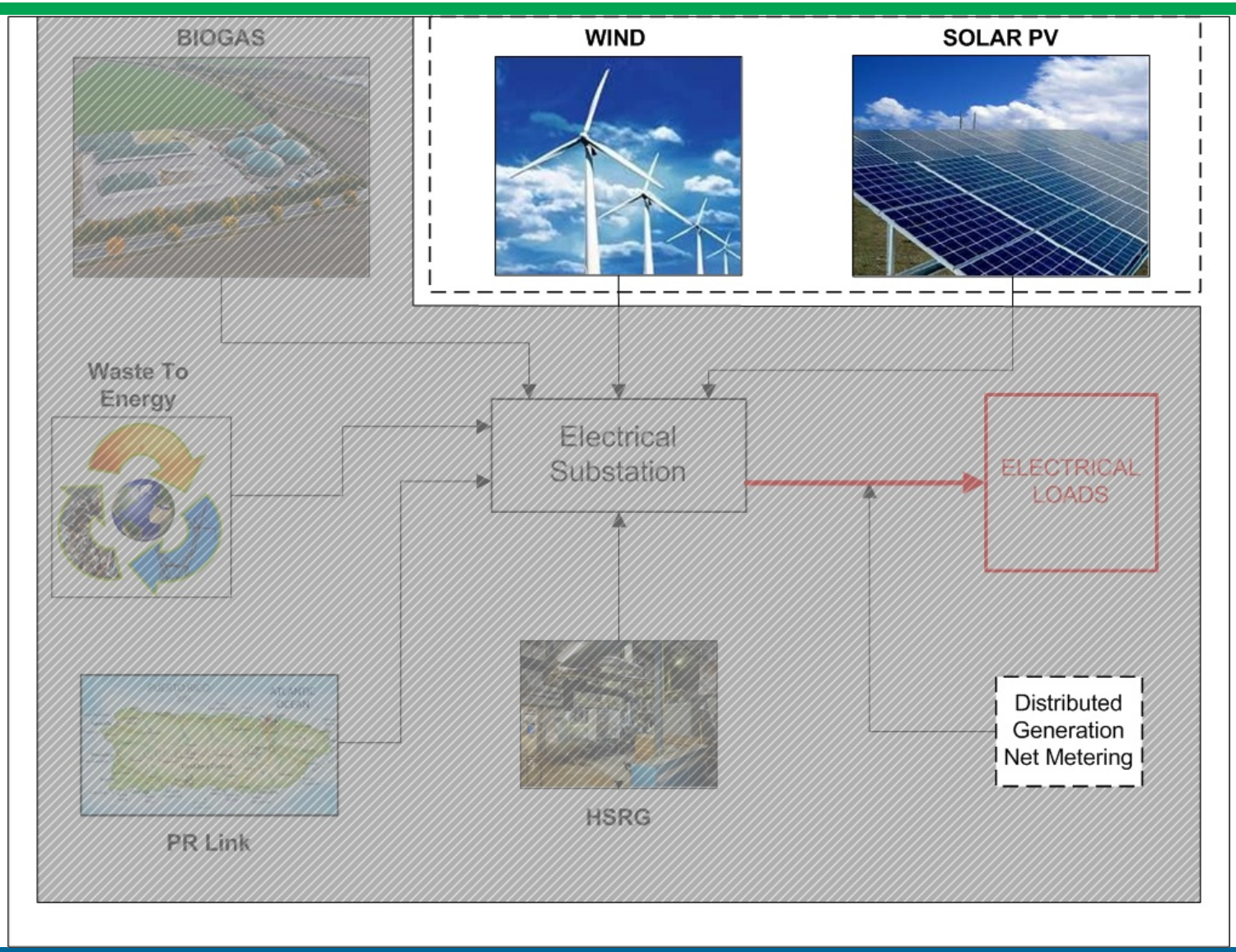
Renewable Generation



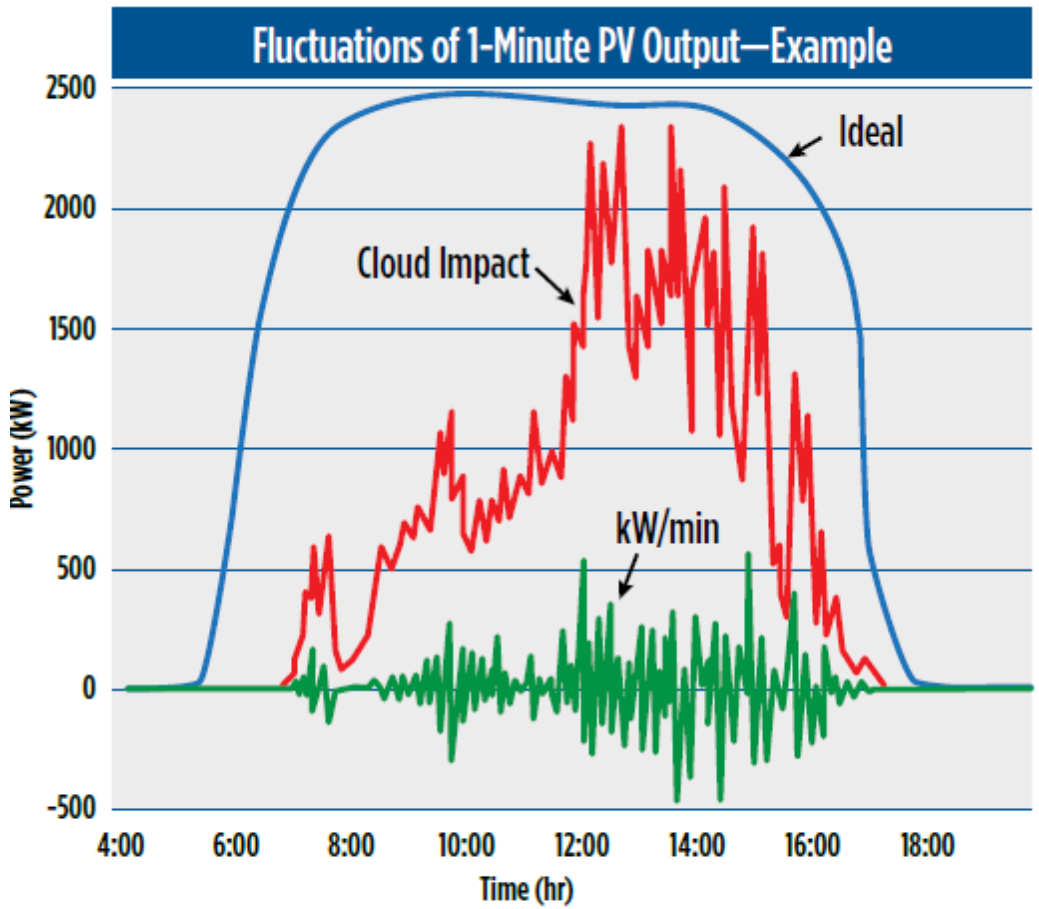
Baseload (Dispatchable)



Intermittent (Non-Dispatchable)



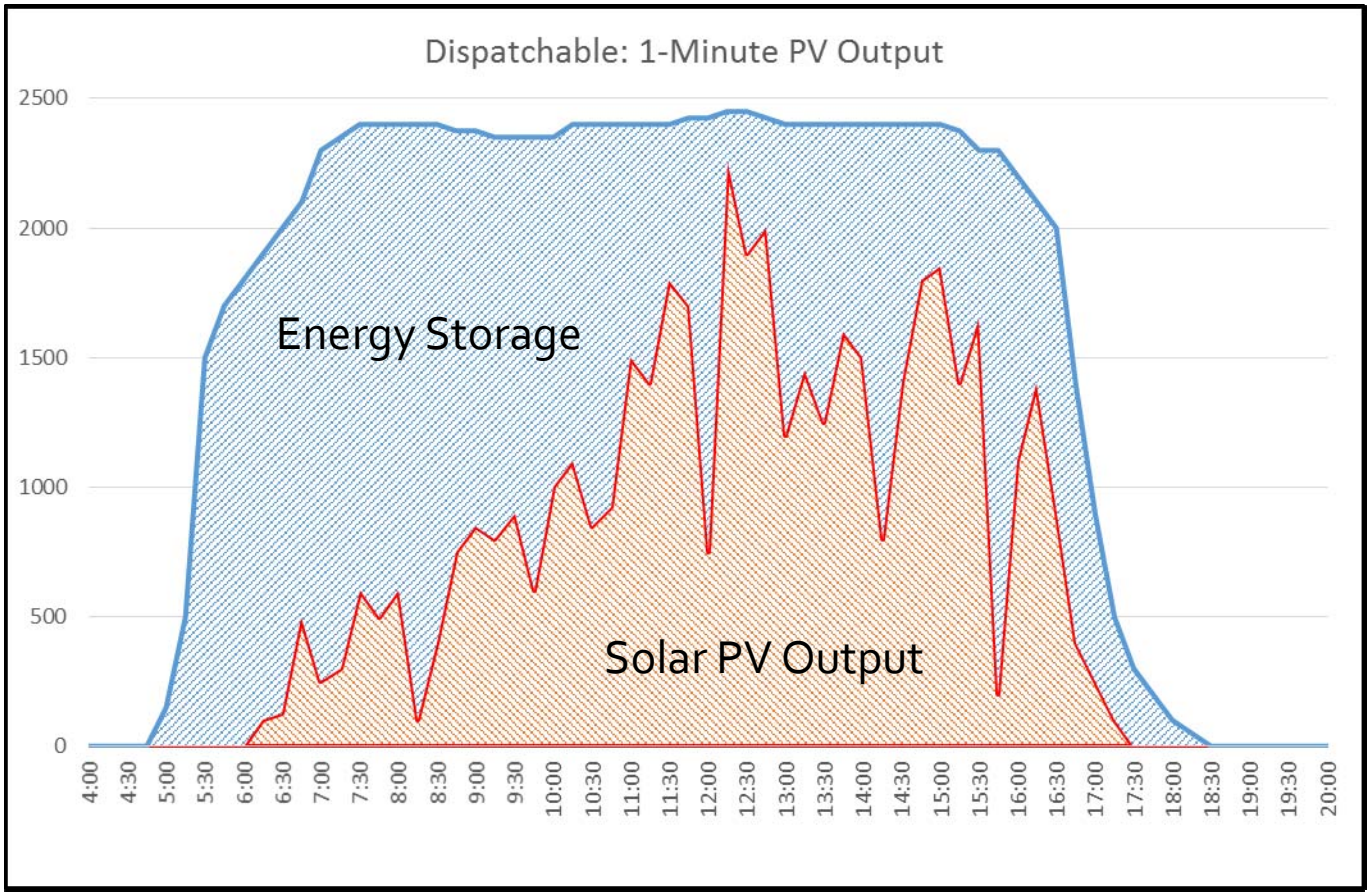
Intermittent (Non-Dispatchable)



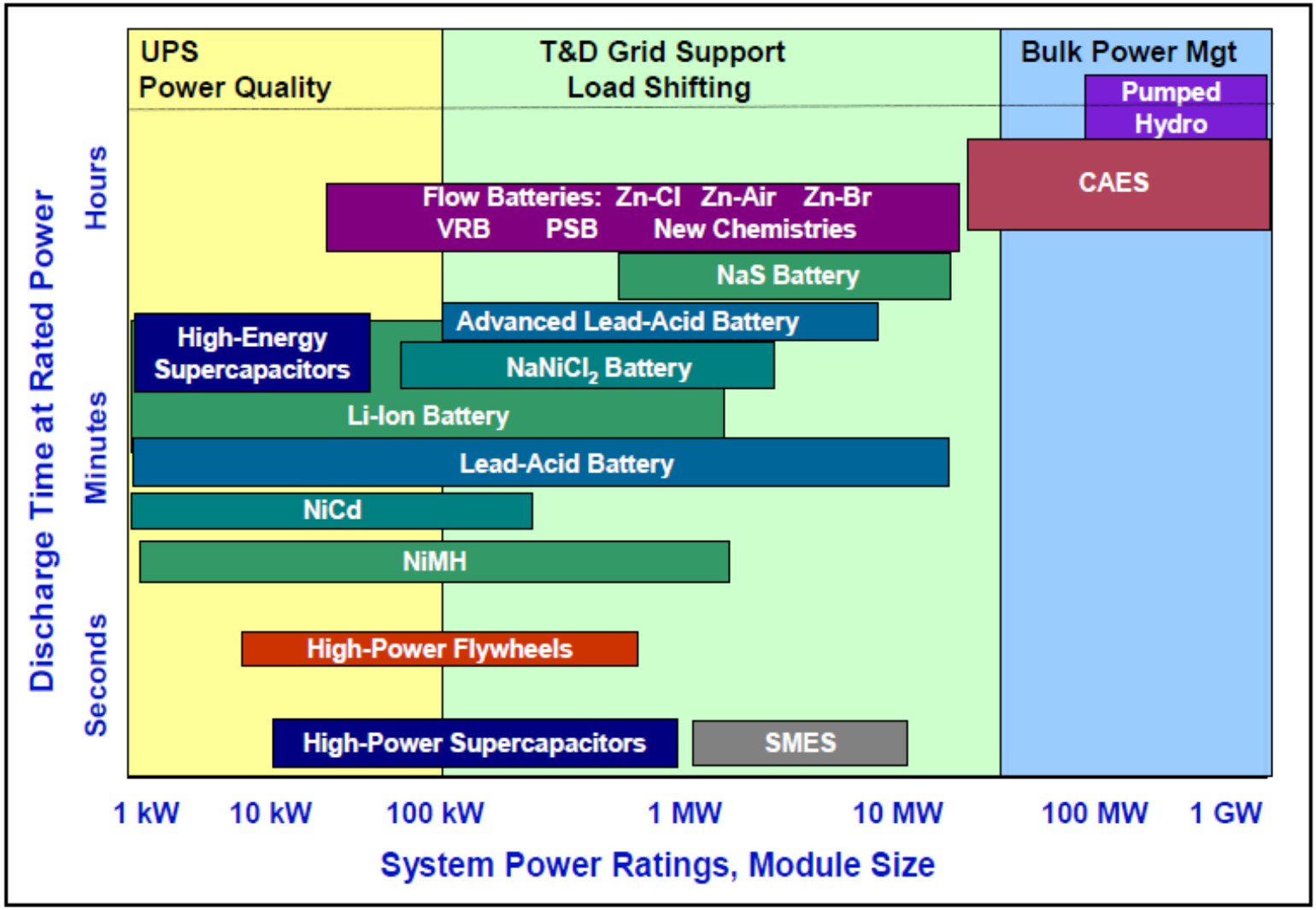
Typical output of a solar system as clouds obscure the sun.

Illustration by NREL

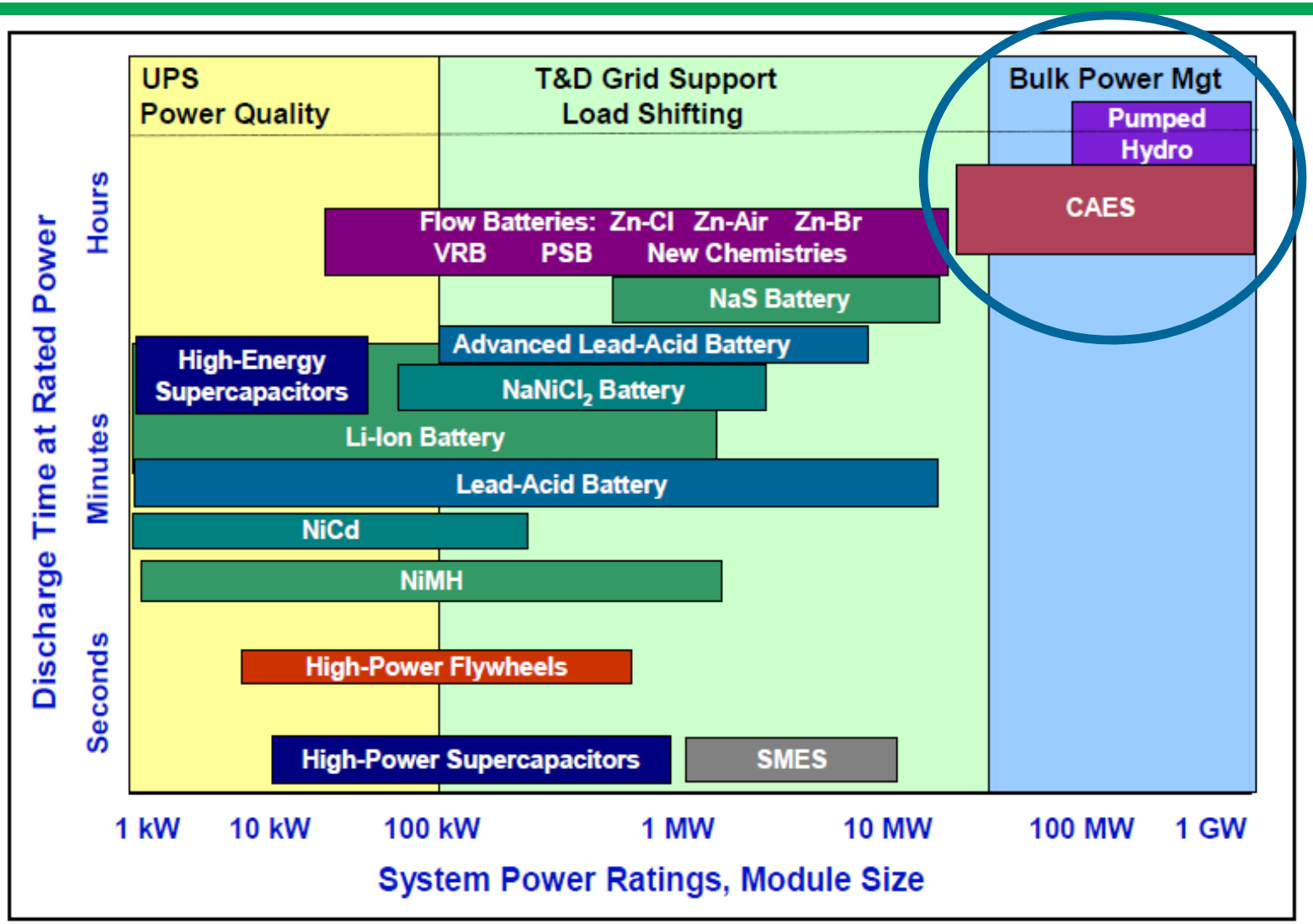
Energy Storage



Energy Storage

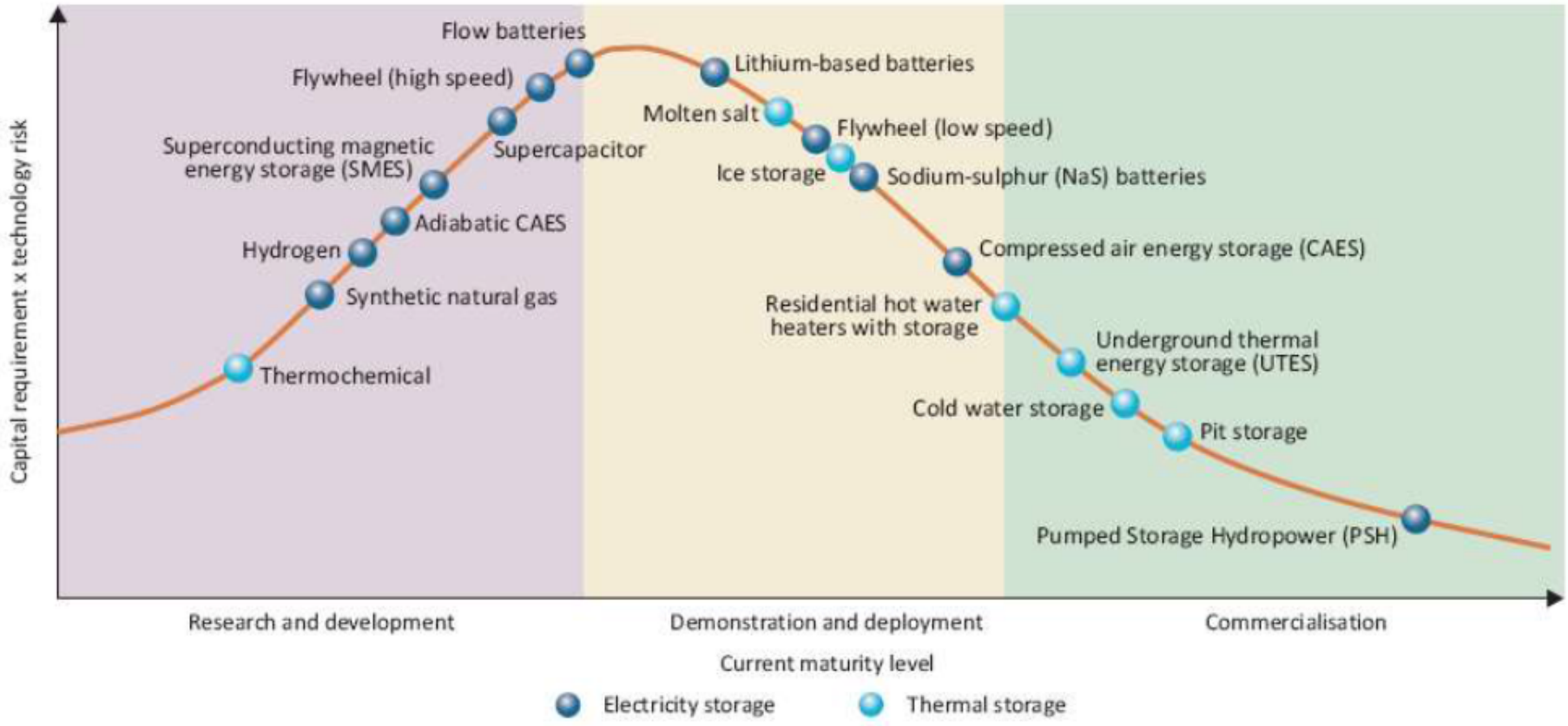


Energy Storage



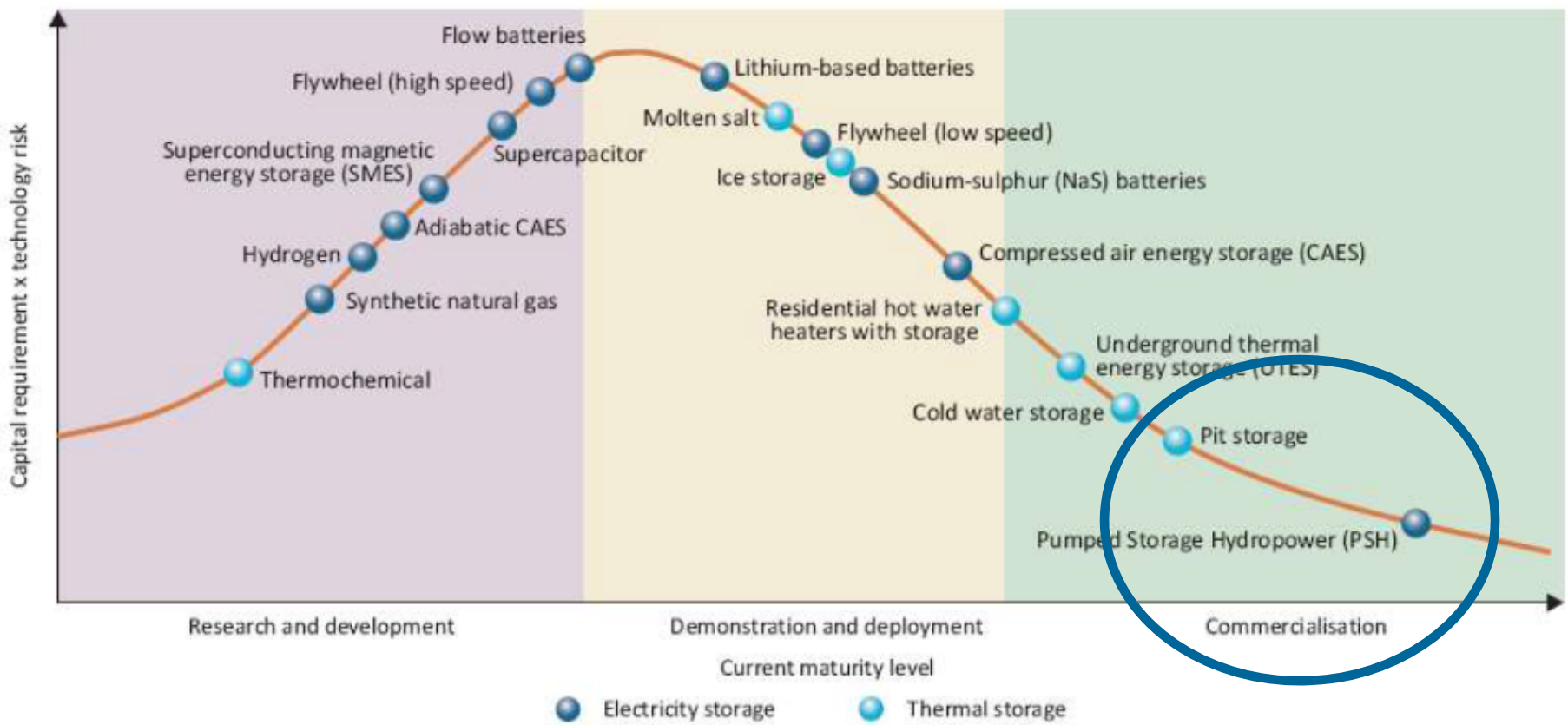
Energy Storage

Figure 1: Maturity of energy storage technologies

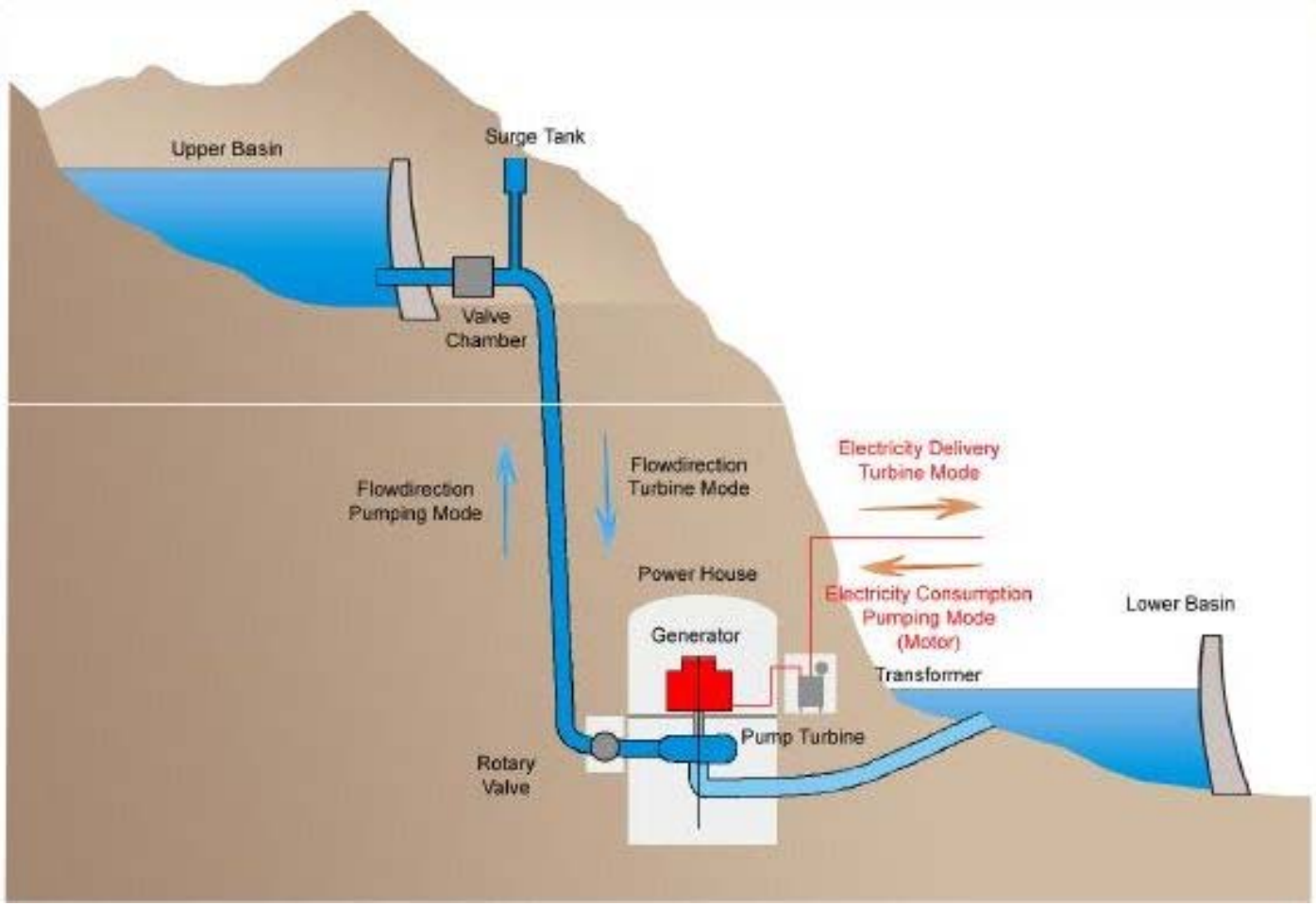


Energy Storage

Figure 1: Maturity of energy storage technologies

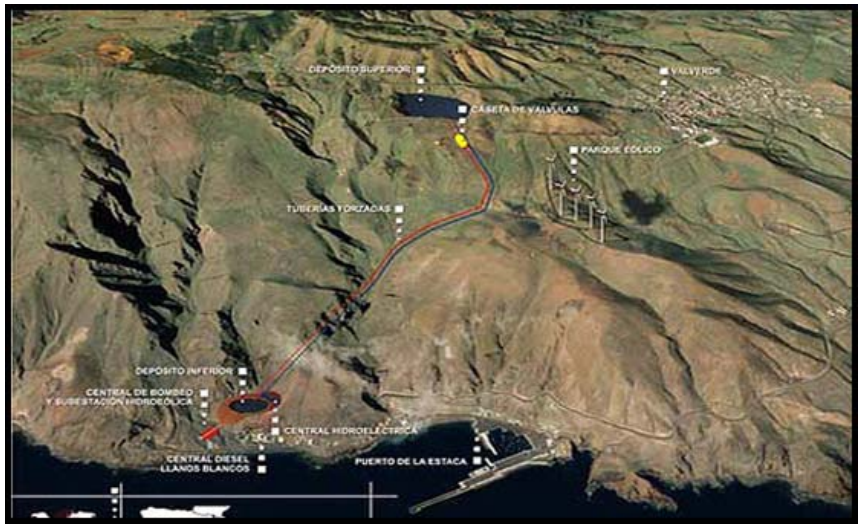


Pumped Hydro Storage



Pumped Hydro Examples

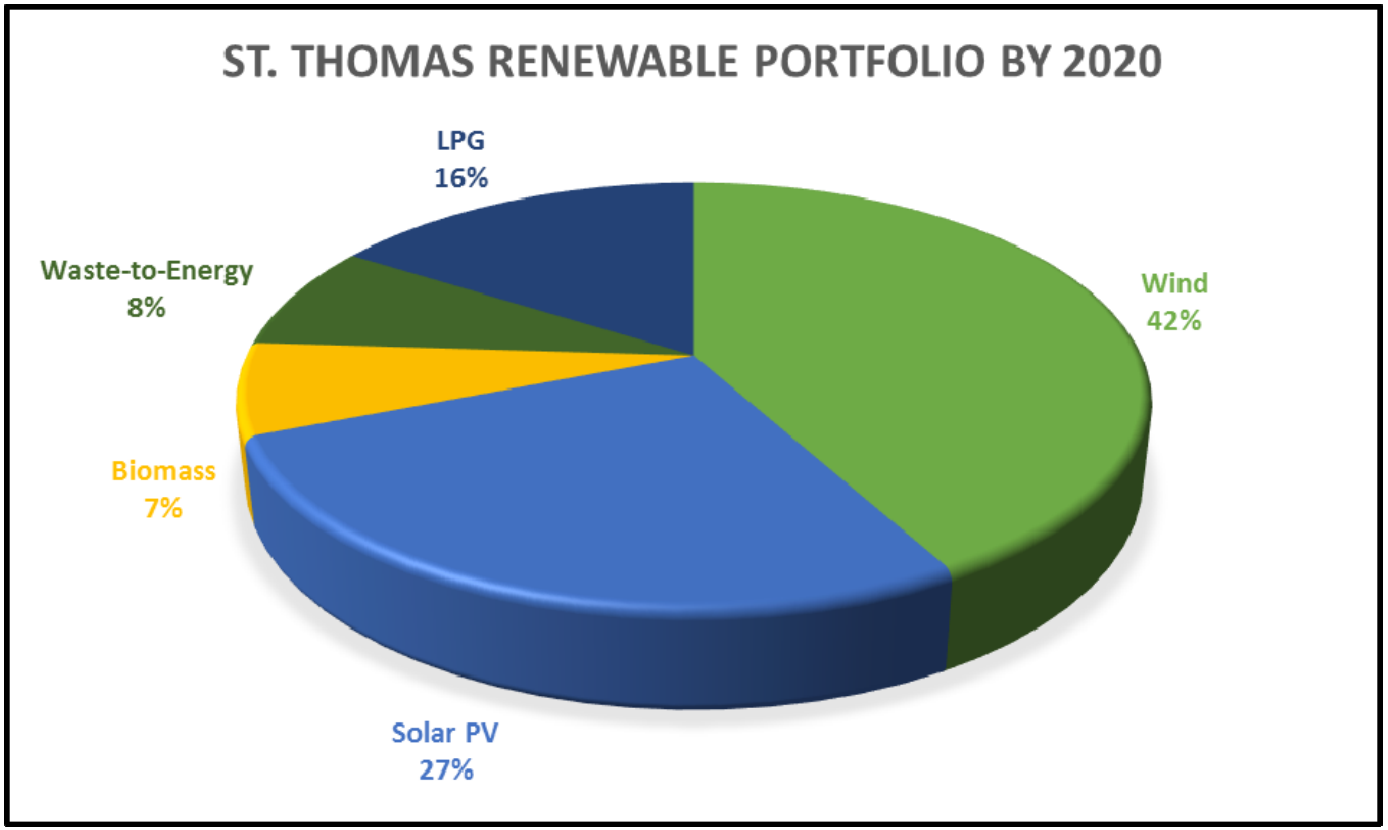
Seawater System - Okinawa



Freshwater System w/ Wind – Canary Islands

Freshwater – Bear Swamp

High Renewable Penetration

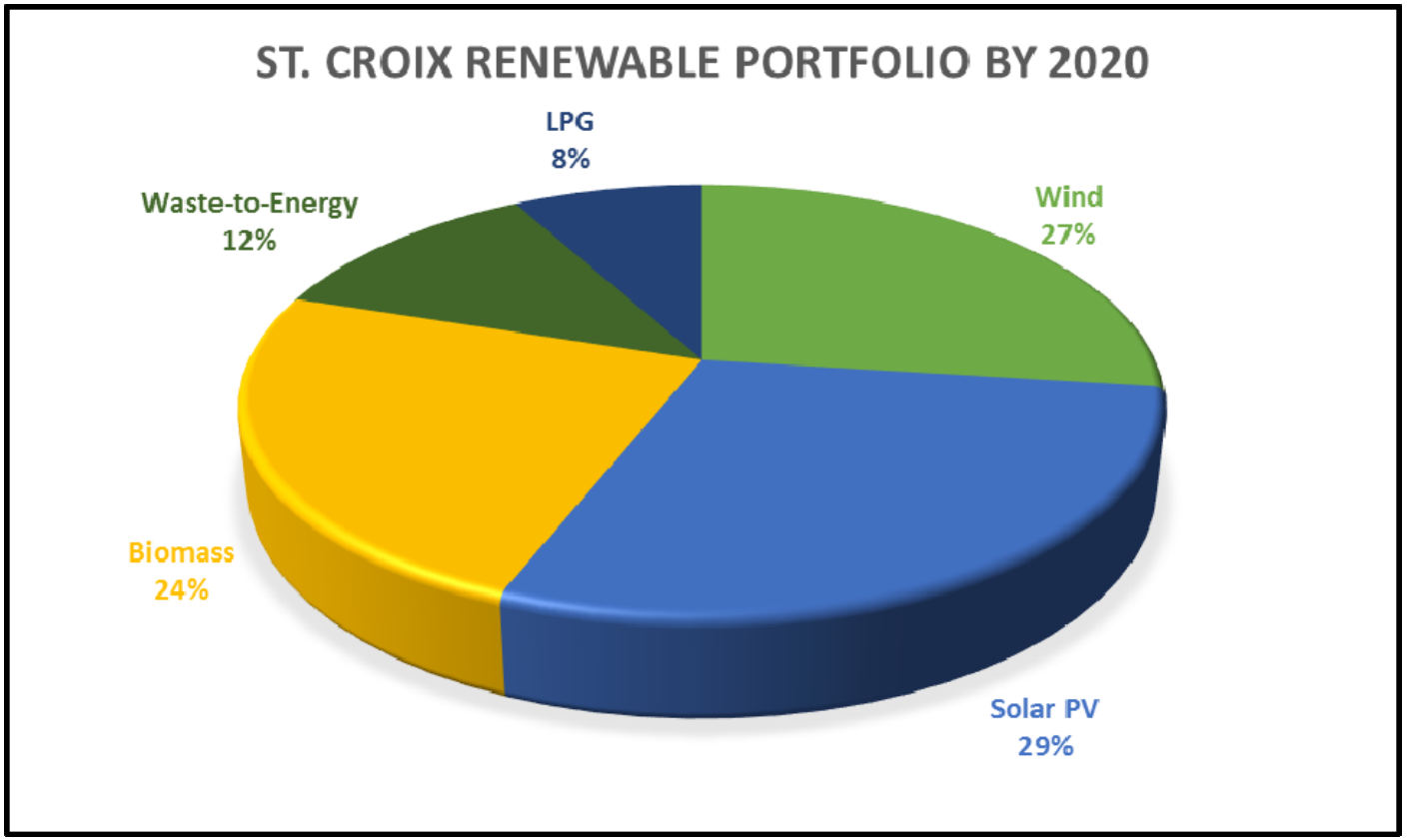


A Renewable Energy + Storage Base for the United States Virgin Islands: Pre-Feasibility Report , October 2014

High Renewable Penetration

Note: 11% of energy output was cycled through storage. With 20% losses, this means that only **2.2% of energy was lost through storage**.

High Renewable Penetration



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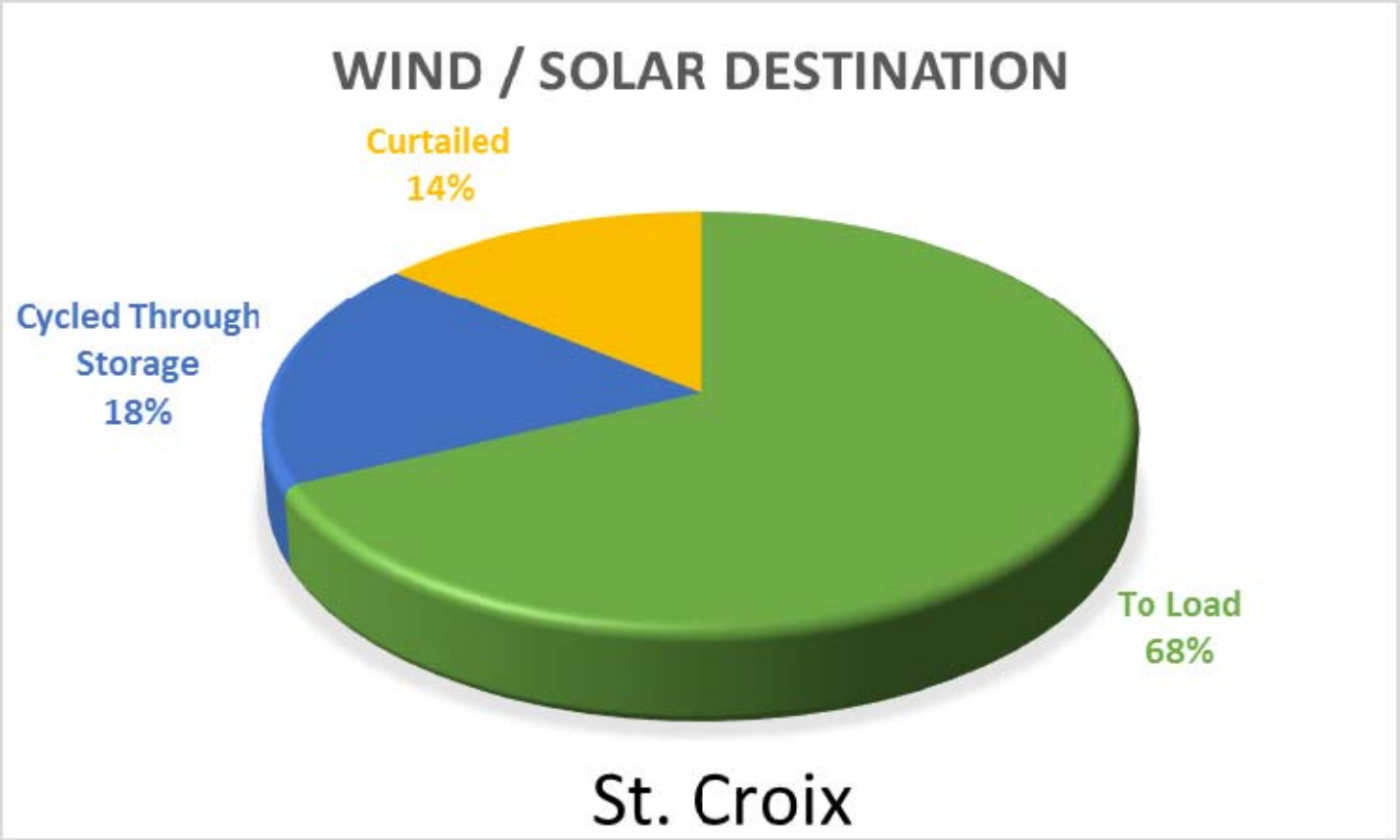
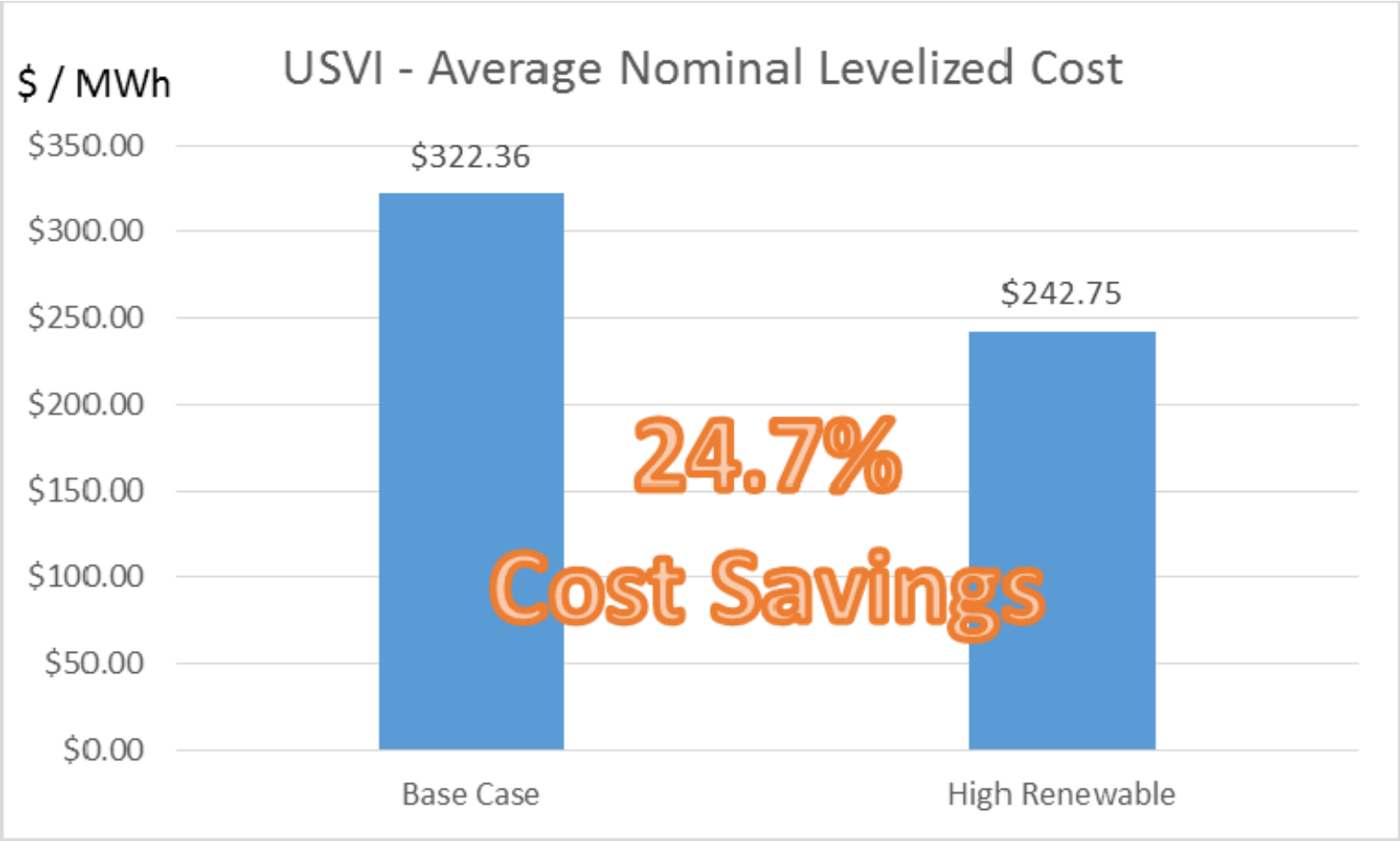
High Renewable Penetration



Note: 18% of energy output was cycled through storage. With 20% losses, this means that only **3.6% of energy was lost through storage**.

Cost Comparison to Roadmap Base Case



Environmental Considerations

POSITIVE IMPACTS

- Reduced Greenhouse Gas & Other Air Pollutant Emissions
- Reduced Risk of Oil Spill Impacts on Marine & Coastal Environments
- Reduced Risk of Gas Leaks & Explosions
- Meeting Territorial Renewable Energy Goals
- Ecotourism & Other *Green* Branding
- Flood Control (Potentially)

Environmental Considerations

POTENTIAL NEGATIVE IMPACTS

- Loss of Terrestrial Habitat (PHS)
- Impacts on Aquifers (brackish or salt H2O)
- Reservoir Failure from Seismic Activity
- **"NIMBY"** Impact (Not-In-My-Back-Yard)

Socio-Political & Economic Benefits

- Reduced electricity cost & volatility
- All capital cost can be privately financed
- Energy-sector jobs & dollars retained locally
- Domestic energy assets utilized, minimizing imported fossil fuels, improving energy security
- Utilizes commercially-proven technologies
- *Green* branding supports eco-tourism
- Meets renewable energy goals and commitments

Socio-Economic Concerns

- Stranded Investment to be mitigated by:
  - Avoidance of new equipment procurement
  - Retiring & phasing out old equipment
  - Retaining equipment as part of diversified energy portfolio and for emergency back-up

- Loss of Fossil Fuel Generation Jobs to be mitigated by:
  - Reducing by attrition
  - New jobs in wind, solar, hydro, WtE, biofuels, etc.
  - Training for 21st century energy-sector jobs

Transition Steps

1. Concept Design & Analysis ✔
2. Site Specific Feasibility Study
3. Permit Approval
4. Construction & Implementation
5. Phased Retirement of Fossil Fuel Generators

SUMMARY

- Over **90% Renewable Energy** Penetration
- Over **24% Reduction** in Electricity Generation Cost
- Reliable and Proven Technology
- Development **100%** Privately **Funded**
- Benefits the economy, public health, the environment and the quality of life

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Additional Information Slides

High Renewable Penetration

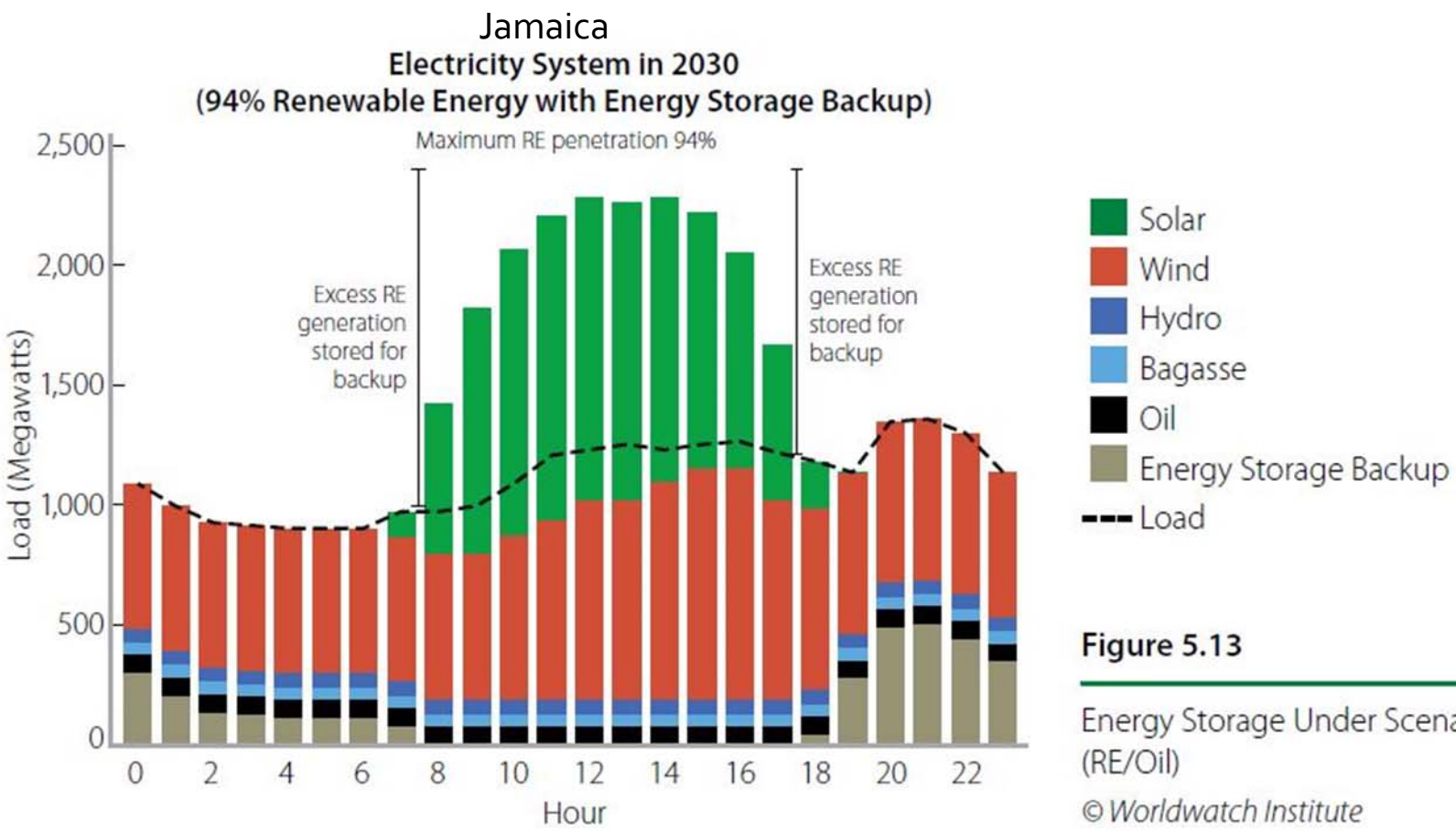

Figure 5.13

Energy Storage Under Scenario 3 (RE/Oil)

© *Worldwatch Institute*

St. Thomas Model vs Base Case

Levelized Nominal Cost, 25 Years, Renewable Supply Base				Includes CO2		
	Resource	MWh	% of Energy Supply	% of Delivered Energy	Nom Lev Cost, $/MWh	Weighted
	Wind	203,250	42%	34%	$191.18	$80.72
	Solar PV	128,703	27%	27%	$178.65	$47.76
	Biomass	31,536	7%	7%	$130.03	$8.52
	Waste-to-Energy	39,420	8%	8%	$194.48	$15.93
	LPG	78,467	16%	17%	$365.37	$59.56
			100%	93%		
	Pumped Storage	33,857		7%	$298.06	$21.41
	Battery	657		0.14%	$1,342	$1.87
	*Wind MWh is net curtailment; F4 calc accounts for wind into storage					
					Sum	**$235.76**
	Energy Total*	481,376	Gross Delivered	471437		
	Total w Storage	515,890				
	Transmission Losses	5.0%				
	Final Renewable Supply Cost					**$247.55**
	Resource	MWh		% of Delivered Energy	Nom Lev Cost, $/MWh	Weighted
	Wind	40,340		9%	$108.73	$9.30
	Solar PV	12,870		3%	$178.65	$4.88
	Biomass	0		0%		
	Waste-to-Energy	39,420		8%	$194.48	$16.26
	LPG	378,806		80%	$365.37	$293.58
		471,437		100%		
					Sum	**$324.02**
	Transmission Losses	5.0%				
	Final Roadmap Supply Cost					**$340.22**
				Cost Difference		($92.67)
				% Difference		**-27.2%**

St. Croix Model vs Base Case

Levelized Nominal Cost, 25 Years, Renewable Supply Base			Includes CO2		
Resource	MWh	% of Energy Supply	% of Delivered Energy	Nom Lev Cost, $/MWh	Weighted
Wind	88,044	27%	15%	$181.62	$48.74
Solar PV	96,527	29%	30%	$179.78	$52.90
Waste-to-Energy	39,420	12%	12%	$194.48	$23.37
Biomass	78,840	24%	25%	$130.03	$31.25
LPG	25,238	8%	8%	$378.33	$29.10
		100%	91%		
Pumped Storage	31,089		10%	$324.60	$31.69
Battery	657		0.21%	$1,342	$2.77
*Wind MWh is net curtailment; F4 calc accounts for wind into storage					
				Sum	**$219.82**
Energy Total*	328,069	Gross Delivered	318393		
Total w Storage	359,815				
Transmission Losses	7.2%				
Final Renewable Supply Cost					**$235.65**

Resource	MWh		% of Delivered Energy	Nom Lev Cost, $/MWh	Weighted
Wind	33,617		11%	$108.73	$11.48
Solar PV	12,870		4%	$179.78	$7.27
Waste-to-Energy	39,420		12%	$194.48	$24.08
Biomass	55,188		17%	$130.03	$22.54
LPG	177,298		56%	$378.33	$210.67
	318,393		100%		
				Sum	**$276.04**
Transmission Losses	7.2%				
Final Roadmap Supply Cost					$295.91
			Cost Difference		($60.26)
			% Difference		**-20.4%**