Options for Wind, Hydro and Wave Systems

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CARILEC
An Association Of Electric Utilities

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Outline

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2. Context
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4. Energy Efficiency and Conversation
5. Options for Wind, Hydro and Wave Systems
6. Increasing the Penetration of RE
7. Issues and Challenges associated with Increasing RE Penetration
8. Possible Solutions
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Brief background on CARILEC

- Regional association of electric utilities, formed in 1989
- Comprised of 33 (Utility) members from around 30 countries in the Caribbean Region
- A Service Corporation
- Main services provided include:
  - Training courses, seminars and conferences
  - Information services
  - Technical studies and surveys
  - Hurricane/ disaster restoration coordination
  - Stakeholder relations

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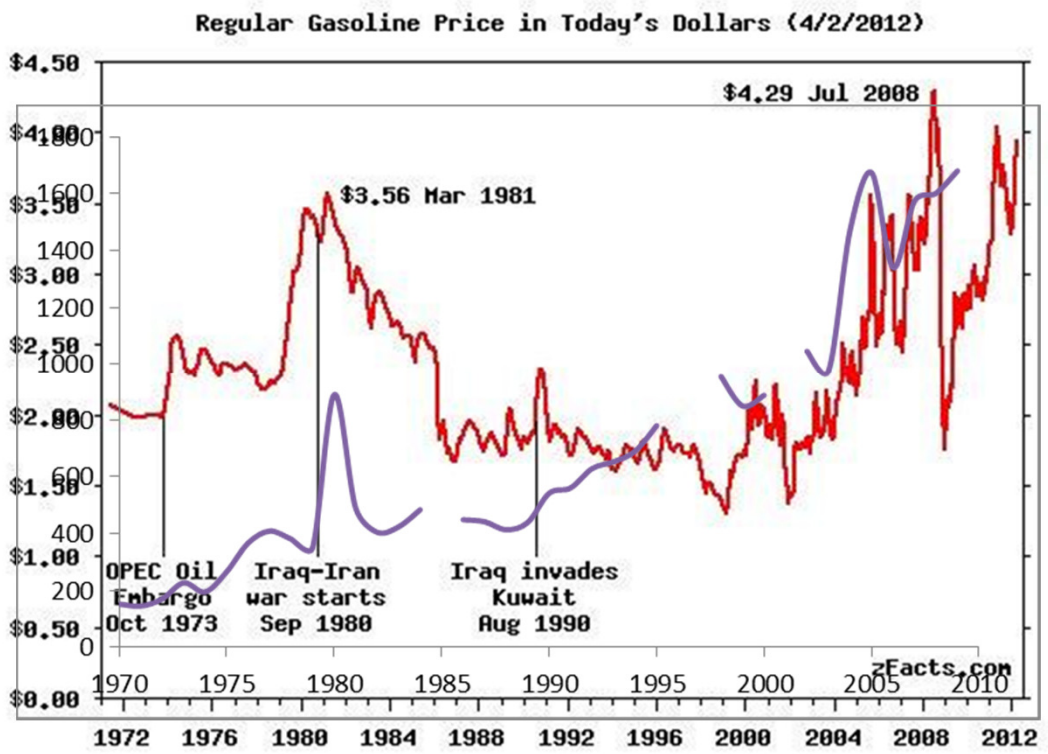
World Oil Prices (1970-2009) vs. Murder Rates



Source: http://www.zfacts.com/prices.htm

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Context

- Jamaica faces several challenges
  - Oil import cost in 2011 was approximately US$2.24 billion (15% of GDP)
  - Environmental concerns (climate change among others)
  - Debt/GDP Ratio – 130%
  - Electricity accounts for 31% of fuel bought, with demand increase approx. 3-4% per annum (need or greed?!!)
  - Electricity prices ~ US$0.35/kWh
  - Largest electricity consumer is government-owned National Water Commission (NWC): bill has exceeded US$4.5 million/month
  - The Jamaican dollar ~ US$1 = JA$86.2
- Drive towards Renewables to mitigate some of the challenges
  - But Renewables present their own set of challenges

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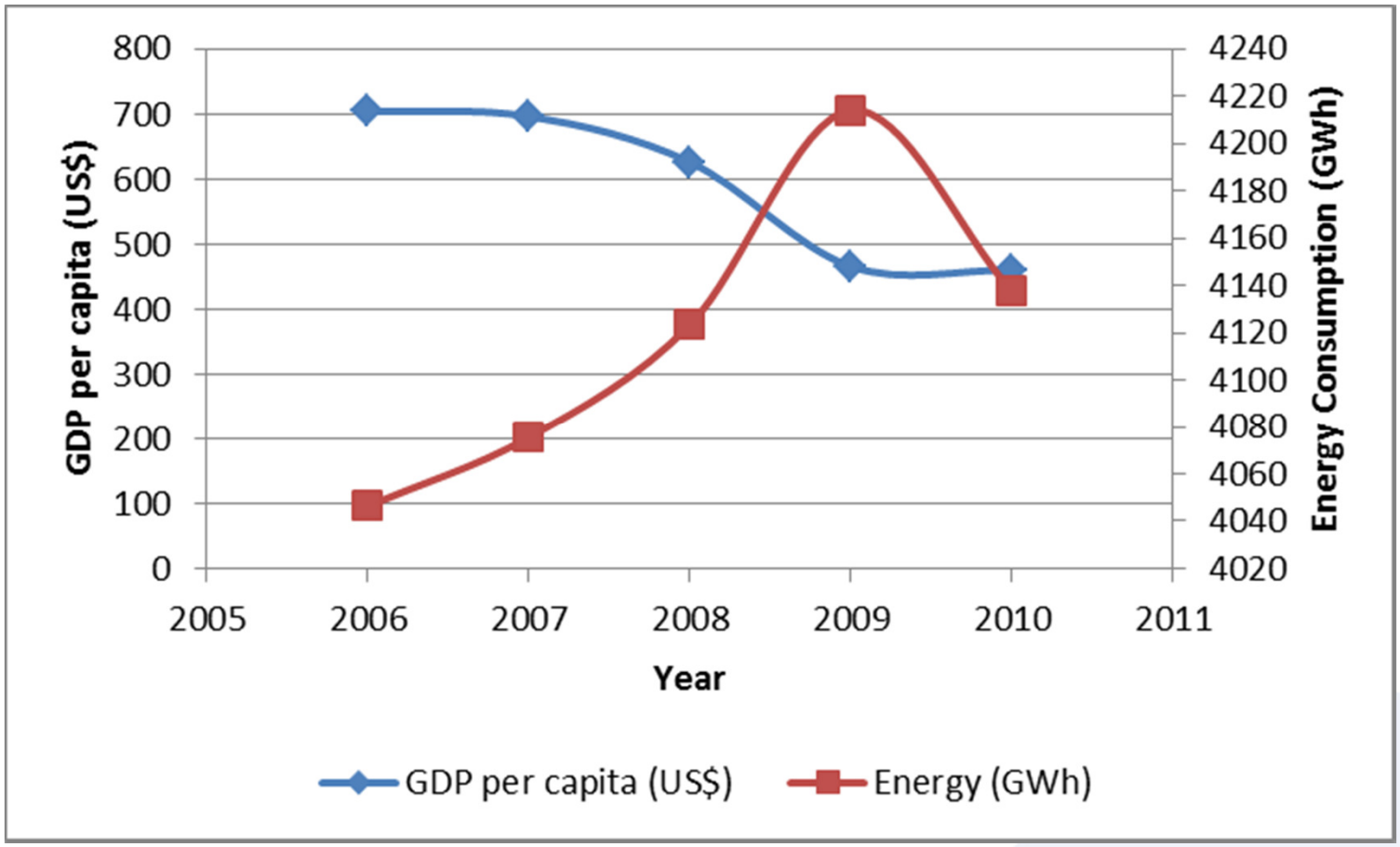
Context



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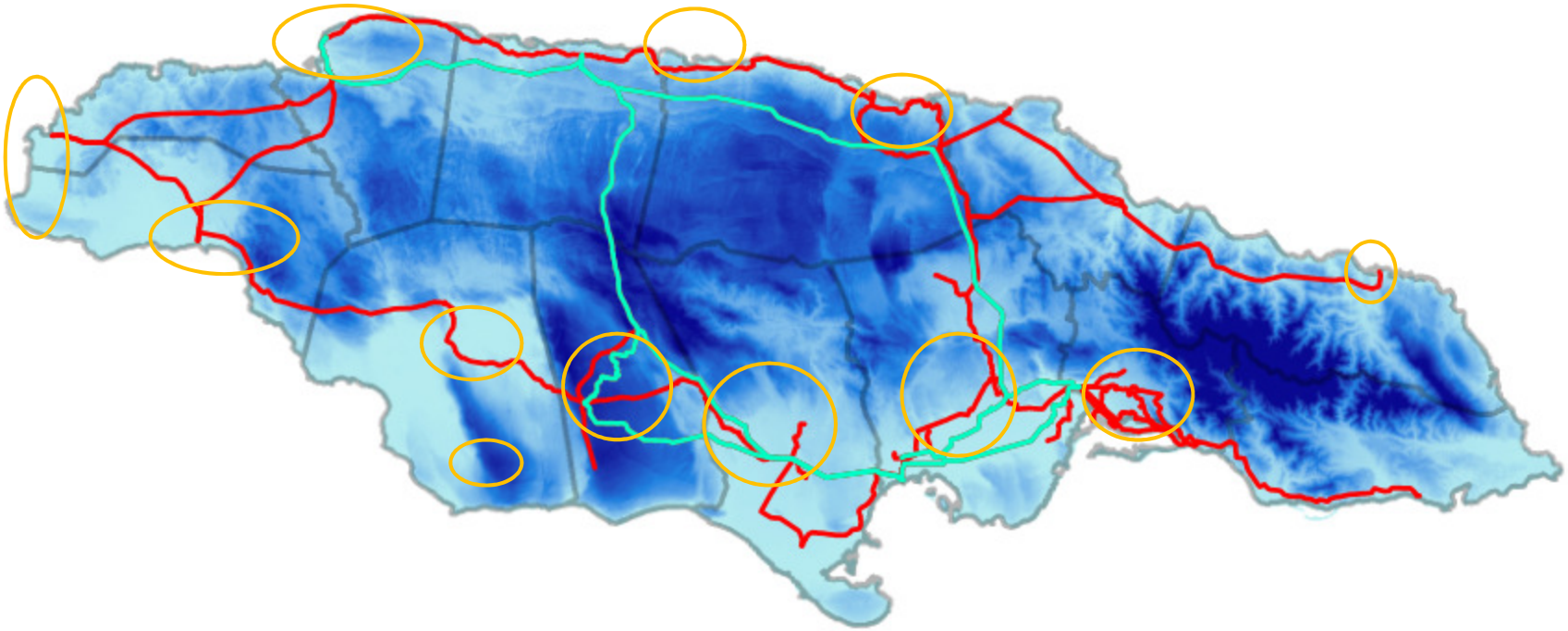
Overview of Jamaica



Integrate Environment and Socio considerations before starting….

- Develop a comprehensive, collaborative and iterative environmental/socio-economic management plan for all phases of RE development
- Conduct an Environmental Impact Assessment as required by local regulations
- Follow best practices and guidelines for environmental and social aspects RE development

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Public Policies

- Environment Policy
- Water Policy: water for life, water for energy
- Energy Policy: energy security / diversification and rural electrification
- Renewable Energy Development
- Distribution Generation
- Land Utilisation
- Energy Consumption

and many more!

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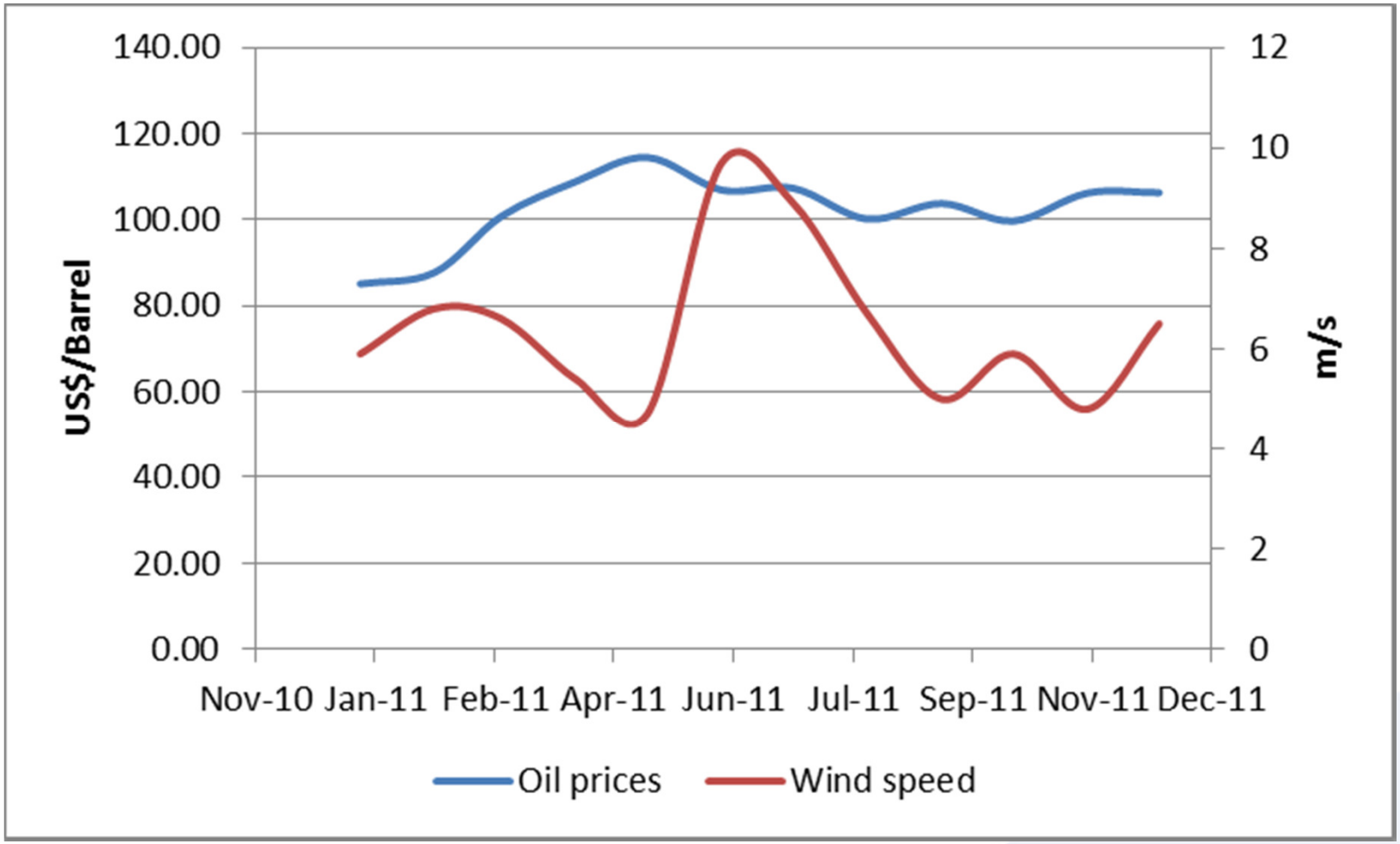
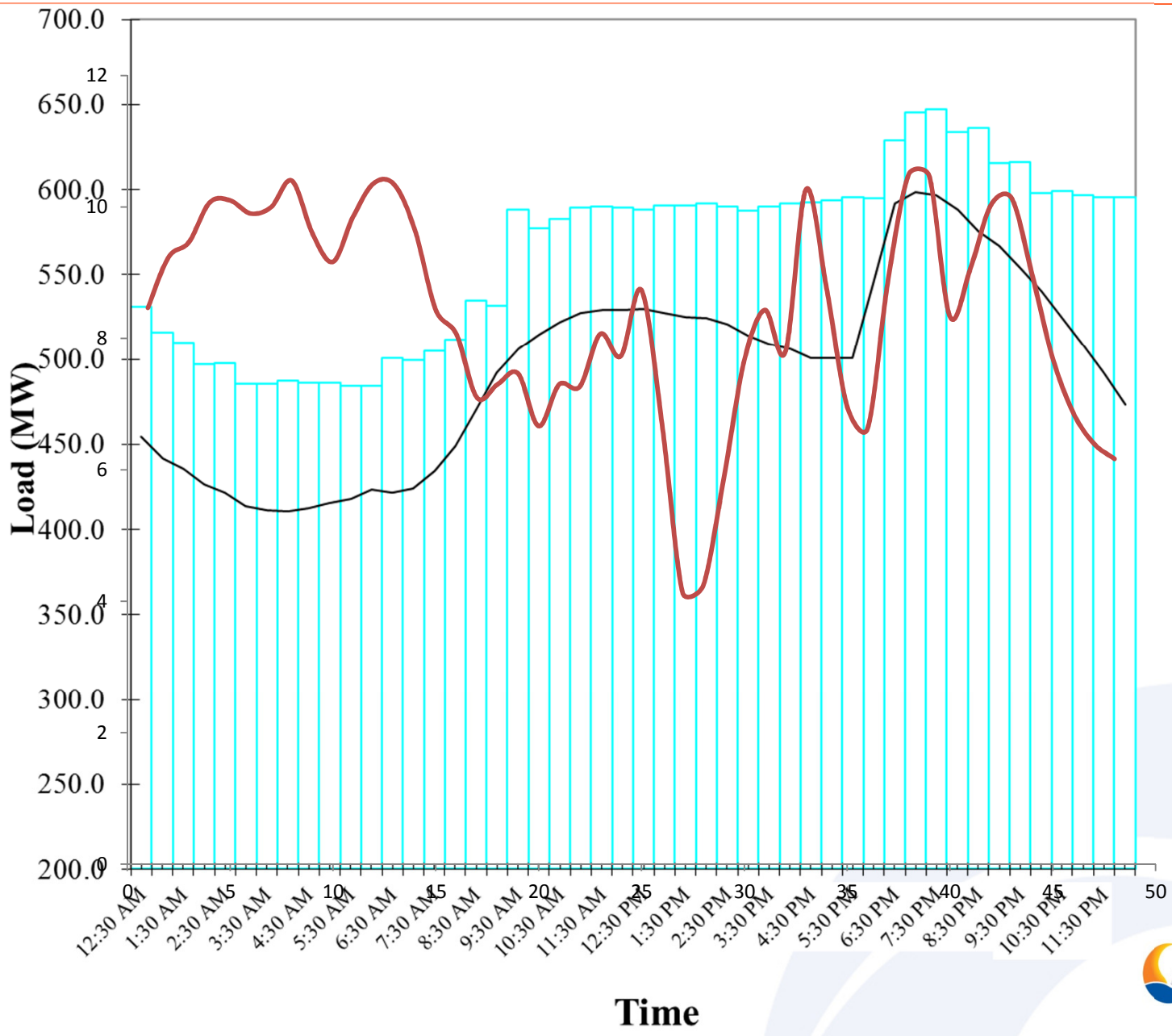
Oil and Wind


140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
US$/Barrel
12
10
8
6
4
2
0
m/s
Nov-10 Jan-11 Feb-11 Apr-11 Jun-11 Jul-11 Sep-11 Nov-11 Dec-11
Oil prices
Wind speed

Spinning Capacity and System Demand… + Wind



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Energy Efficiency and Conservation

- The efficient and effective use of energy is pivotal to our competiveness and sustainability.

- Energy Management programs include:
  - Improving energy efficiency and reducing energy use, reduces cost
  - Reduce greenhouse gas emissions and improve air quality
  - Cultivating good communications on energy matters
  - Developing and maintaining effective monitoring, reporting and management strategies
  - Reduce the impacts of curtailments, brownouts, or any interruptions in energy supplies

RE Options

- Are our options …
  - Desirable
  - Applicable
  - Feasible or Achievable
  - Reliable
  - Viable or equitable

RE Options

- Factors to consider
  - Access to the site of the resource
  - The availability of the resource
  - The reliability of the resource
  - The off-taker of the power generated
  - The Permit requirements
  - The Technology
  - The Cost
  - The Financing

The case of Wind Energy

$$P_{wind} = \frac{1}{2}\rho A U^3 C_p$$

The wind speed is retarded frictional forces on the earth's surface as a result the speed increases in height. The wind is variable may not match demand.

Wind Energy Technology have benefitted from advances in the technology (Wigton I vs Wigton II).They are more resilient to harsh weather systems and have the advantage of lower maintenance and operation cost than previous designs

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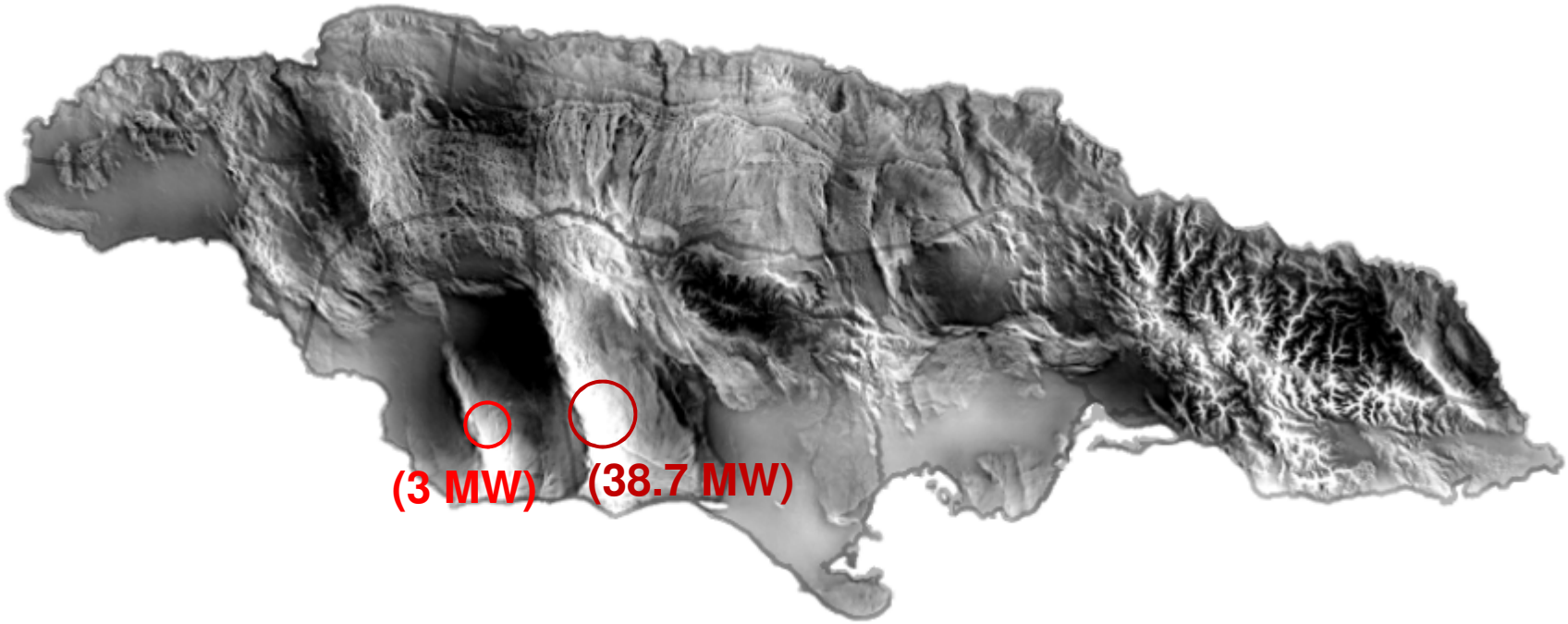
Options for Wind Systems



The case of Hydro Power

$$P_{hydro} = Q\rho gH(\eta)$$

The hydro system exploits the potential energy of the water. That means the source originates in Mountainous areas. The flow varies throughout the year.

There has been improvements in the material and technology to improve efficiency and lower capital cost. Hydro power facilities has a long life cycle. May operate as a base load plant depending on the design and resource

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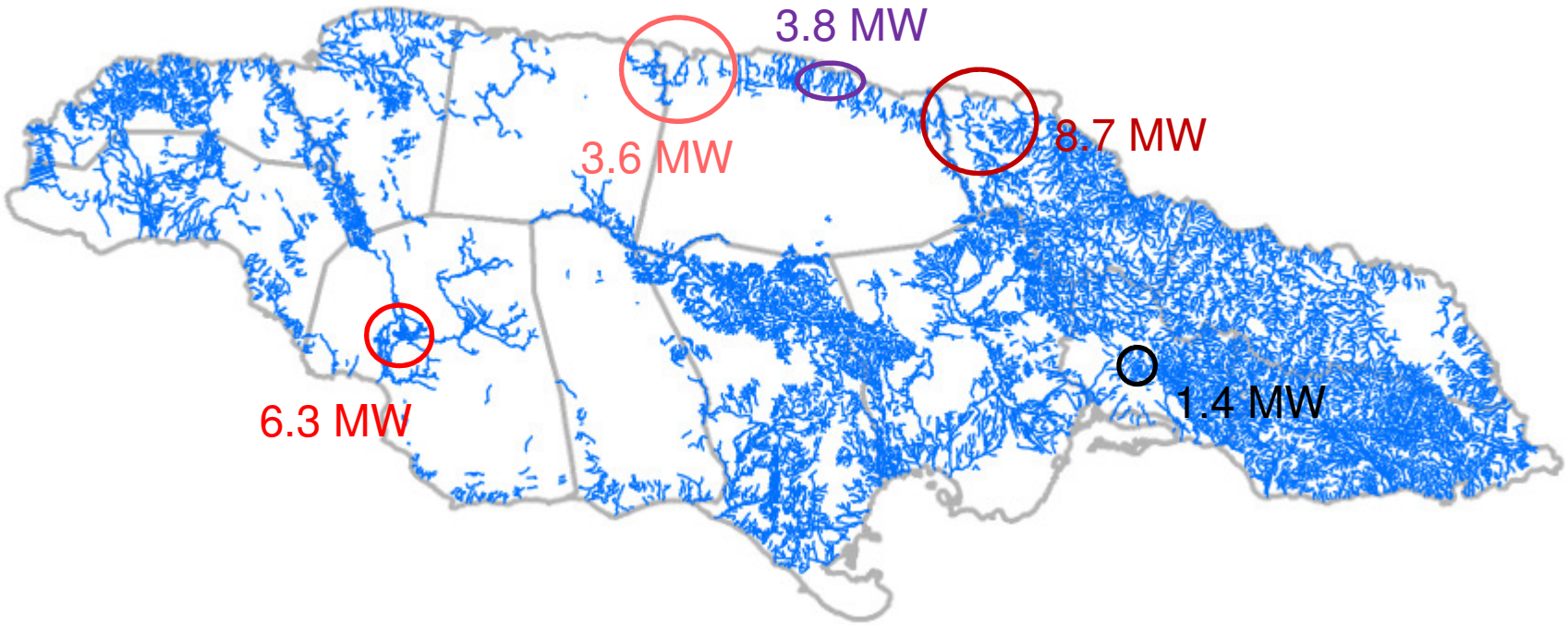
Options for Hydro Systems



The case of Wave Power

$$P_{wave} = 0.05\rho g H^2 T$$

Wave Power is an emerging power generator. There are a number of technologies launched in the last 15 years.

There are opportunities for Jamaica to develop machines conducive for the local conditions

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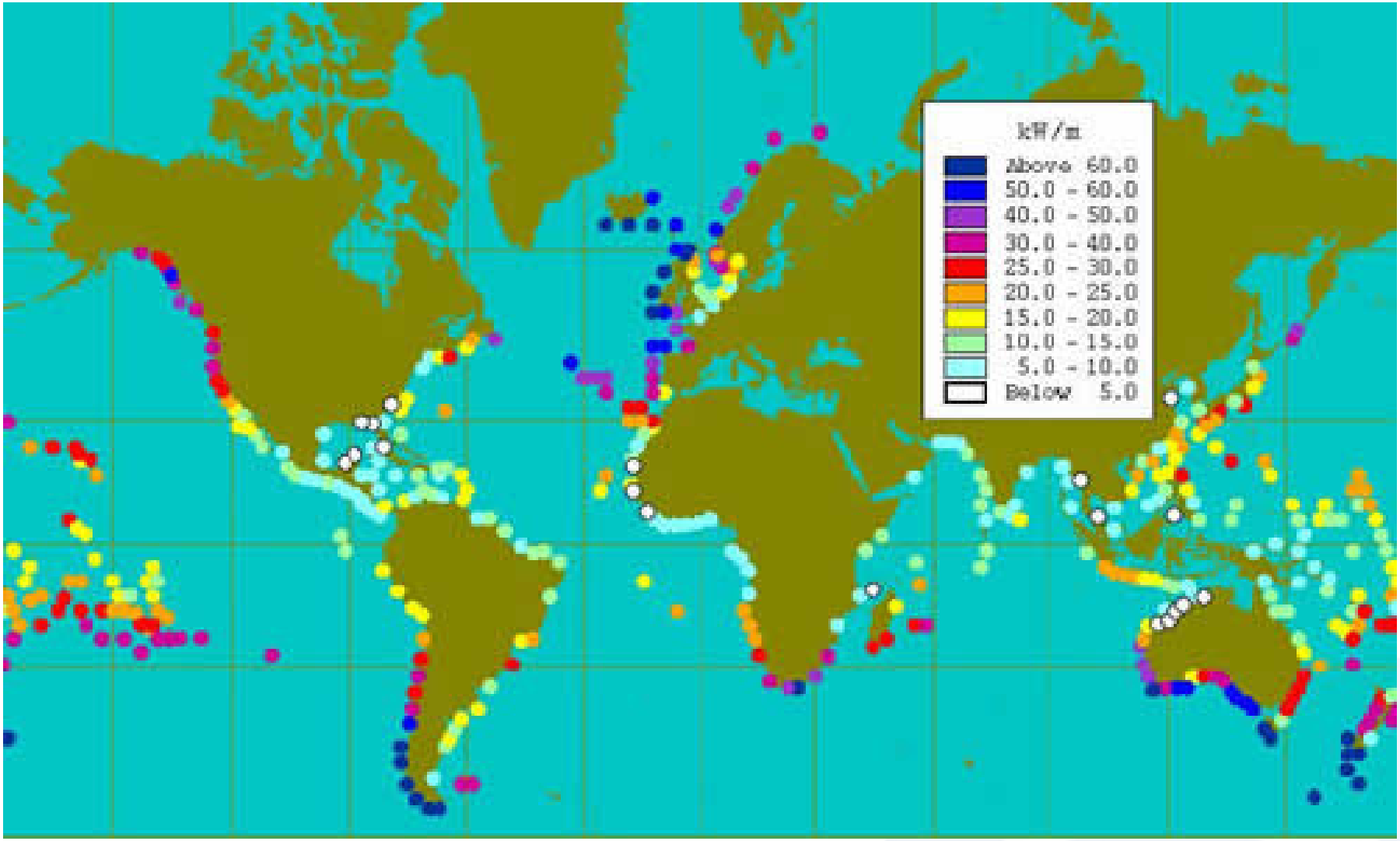
Options for Wave Systems



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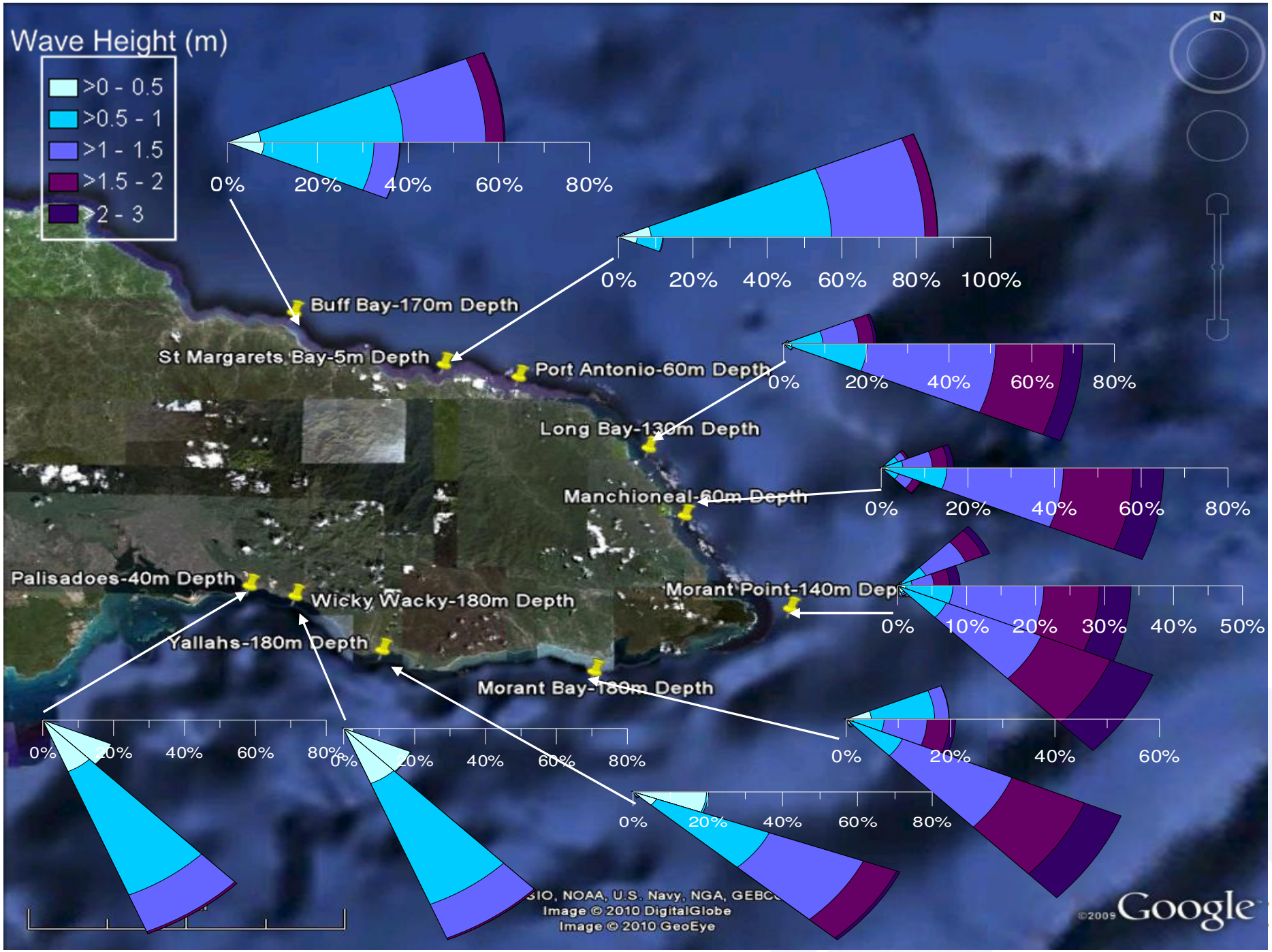
Wave Height (m)
>0 - 0.5
>0.5 - 1
>1 - 1.5
>1.5 - 2
>2 - 3
Buff Bay-170m Depth
St Margarets Bay-5m Depth
Port Antonio-60m Depth
Long Bay-130m Depth
Manchioneal-60m Depth
Palisadoes-40m Depth
Wicky Wacky-180m Depth
Morant Point-140m Dep
Yallahs-180m Depth
Morant Bay-180m Depth
0% 20% 40% 60% 80%
0% 20% 40% 60% 80% 100%
0% 20% 40% 60% 80%
0% 20% 40% 60% 80%
0% 10% 20% 30% 40% 50%
0% 20% 40% 60% 80%
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0% 20% 40% 60% 80%
Image © 2010 DigitalGlobe
Image © 2010 GeoEye
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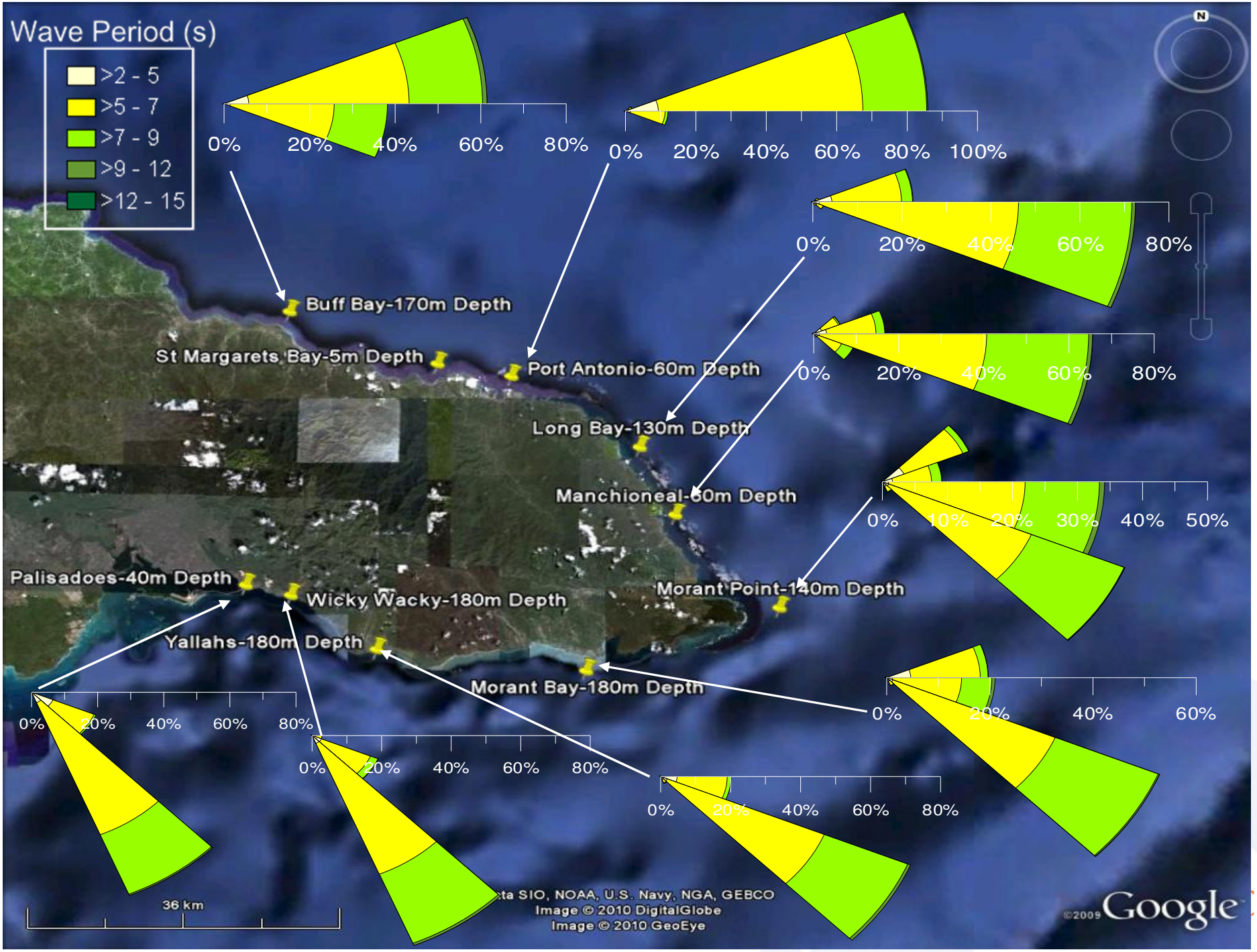
Wave Period (s)
>2 - 5
>5 - 7
>7 - 9
>9 - 12
>12 - 15
Buff Bay-170m Depth
St Margarets Bay-5m Depth
Port Antonio-60m Depth
Long Bay-130m Depth
Manchioneal-60m Depth
Palisadoes-40m Depth
Wicky Wacky-180m Depth
Morant Point-140m Depth
Yallahs-180m Depth
Morant Bay-180m Depth
0% 20% 40% 60% 80%
0% 20% 40% 60% 80% 100%
0% 20% 40% 60% 80%
0% 20% 40% 60% 80%
0% 10% 20% 30% 40% 50%
0% 20% 40% 60%
36 km
ta SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 DigitalGlobe
Image © 2010 GeoEye
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Wind and Hydro Potential within Jamaica

- Potential Capacity (MW)

Wind	70 – or more
Back Rio Grande (BRG)	28?
Great River	8
Green River	1.4?
Laughlands Great River	2
Martha Brae River	4.8?
Morgans River	2.3?
Negro River	1?
Rio Cobre	1?
Spanish River	2.5?
Wild Cane River	2.5?
Yallahs River	2.6?

Source: The Petroleum Corporation of Jamaica Group

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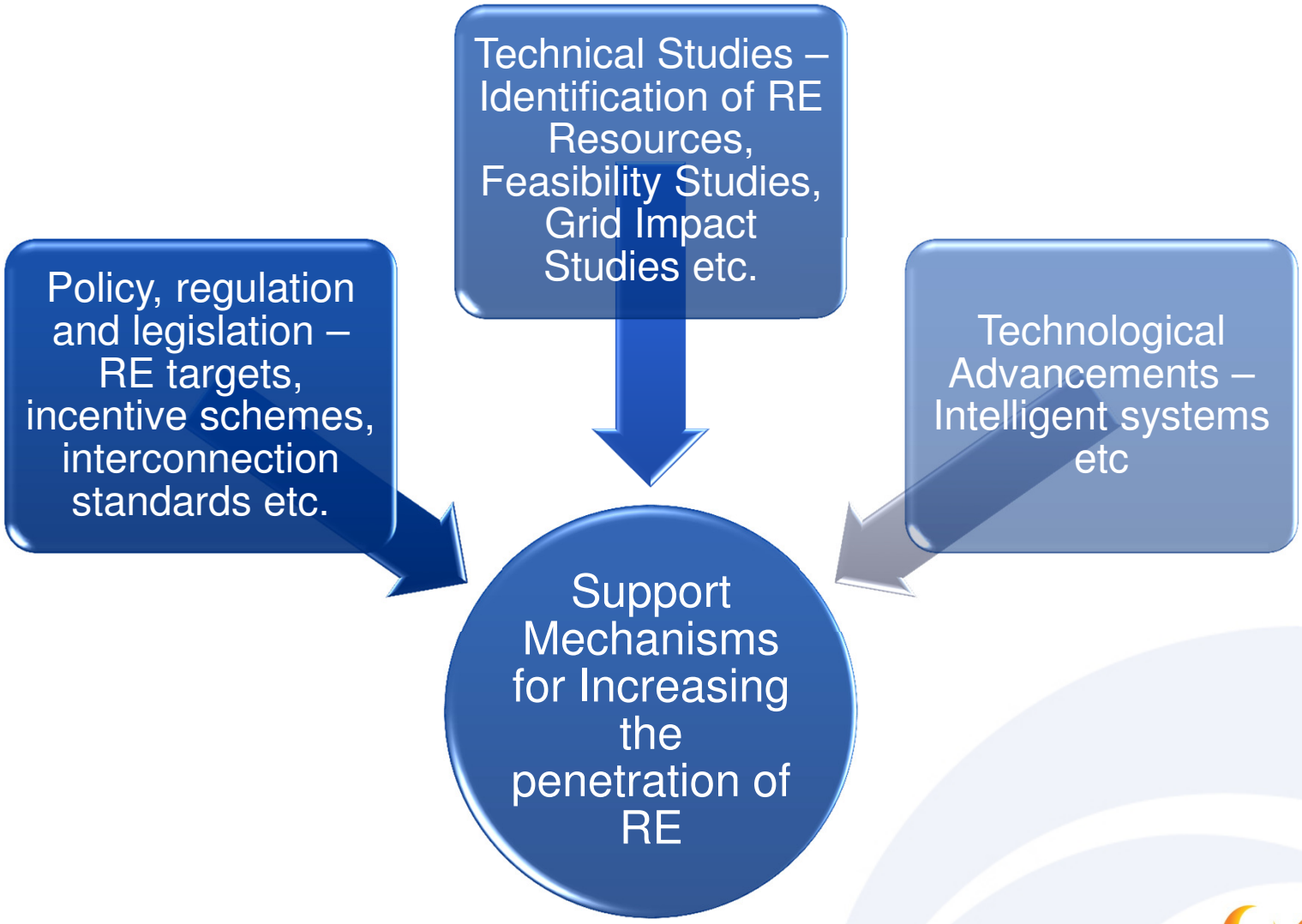
Increasing RE Penetration



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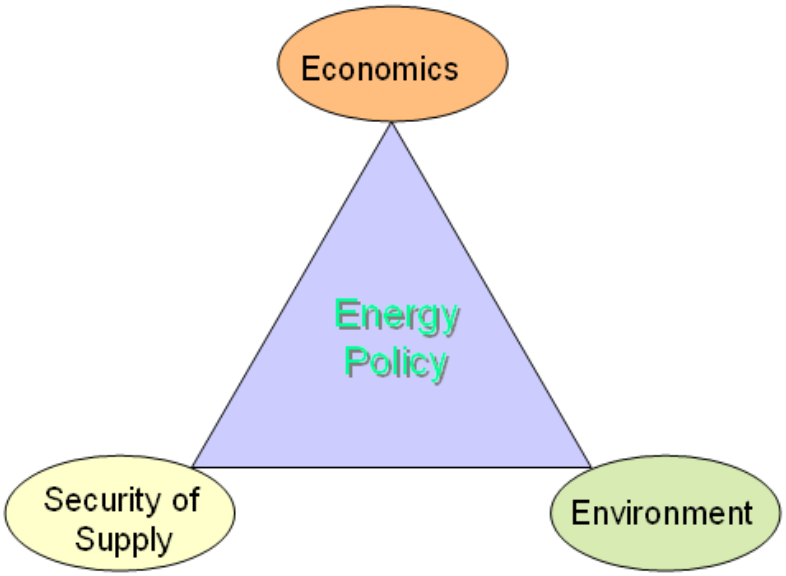
Increasing the Penetration of RE: Policy Objectives

- Increase market penetration of renewables

Wider policy objectives:



- Environmental imperatives
  - GHG emission reduction
- Security of supply
  - diversification of electricity portfolio
  - Reduce reliance on imported fuel stock
- Economic / industrial policy considerations
  - Create new industries and jobs in the RES-E supply chain
  - Drive technological innovations

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Factors to Consider…

Renewable energy plants costs are dependent on several parameters and characteristics

Inter-technology variations	• Wind, hydro, wave etc.
Intra-technology variations	• Onshore vs. offshore wind
Scale	• Economies vs. diseconomies of scale
Local conditions	• Quality of renewable energy resource (e.g., level of wind speeds at sites etc.)

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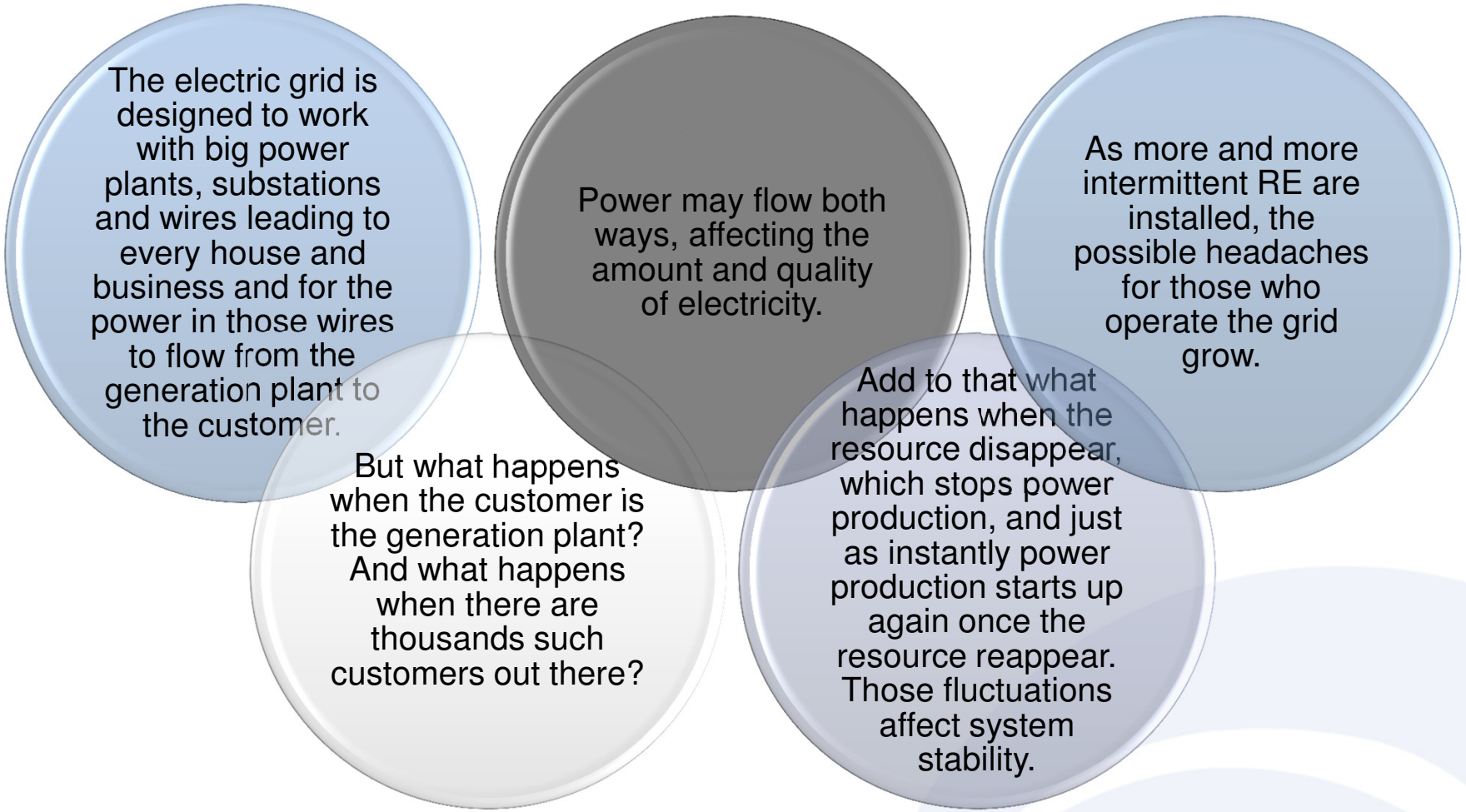
How much RE power can the grid take?



The industry is working on resolving these issues…

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Issues associated with increasing RE

Developing RE resources presents a new set of technological challenges not previously faced by the grid:

- The location of renewable resources far from population centres
- The variability of renewable generation.

In general, small penetrations of renewable generation on the grid can be smoothly integrated.

- In general, accommodating more than approximately 30% electricity generation RE will require new approaches to extending and operating the grid.
- Studies need to be done to confirm this % for Jamaica

The variability of renewable resources, due to characteristic fluctuations, introduces uncertainty in generation output on the scale of seconds, hours and days.

- These uncertainties, can affect over 70% of hydro power due to droughts and up to 100% of wind and wave capacity on calm days for individual generation assets.

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Issues associated with increasing RE

The variability of renewable energy is easily accommodated when demand and renewable supply are matched – both rising and falling together.

- However when demand and RE supply move in opposite directions, the cost of accommodation can rise significantly.
- For example, on calm days, when there is no wind power, the late-afternoon peak demand must be met entirely by conventional generation resources, requiring reserves that effectively duplicate the renewable capacity.
- As renewable generation grows it will ultimately overwhelm the ability of conventional resources to compensate renewable variability, and require the capture of electricity generated by wind, water and other renewables for later use.

The integration of significant amounts of renewable electricity will require upgrades to the national grid, which was designed for centralized production.

- High renewable energy penetrations in electricity industries may increase uncertainties during abnormal electricity industry operating conditions.
- It would be valuable to have mathematical models that could adequately predict industry behaviour with high renewable energy penetration.
- New interconnections and intelligent systems will ultimately be required to handle decentralized, intermittent sources of renewable power.

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Load Flow and Power System Simulation

- Load Flow – Power flow calculations that follow a structured procedure as it relates to multiple interconnected lines
  - It provides information about voltages, currents and complex power flows throughout the network at a particular point in time, with a given set of load and generation conditions
  - Other information such as losses and loadings can be calculated

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Load Flow Analysis

- Load Flow Analysis provide the following vital information for design as well as the operation and control of power system

  - Checking whether an equipment run within their rated capacity
  - Checking that voltage throughout the network are kept within acceptable limits
  - Ensuring that the power system is run as efficient as possible
  - Ensuring that the protection system will act appropriately under fault conditions
  - Assisting with the planning of expansion of conventional and renewable generation and the necessary strengthening of T&D system for future power demand increases

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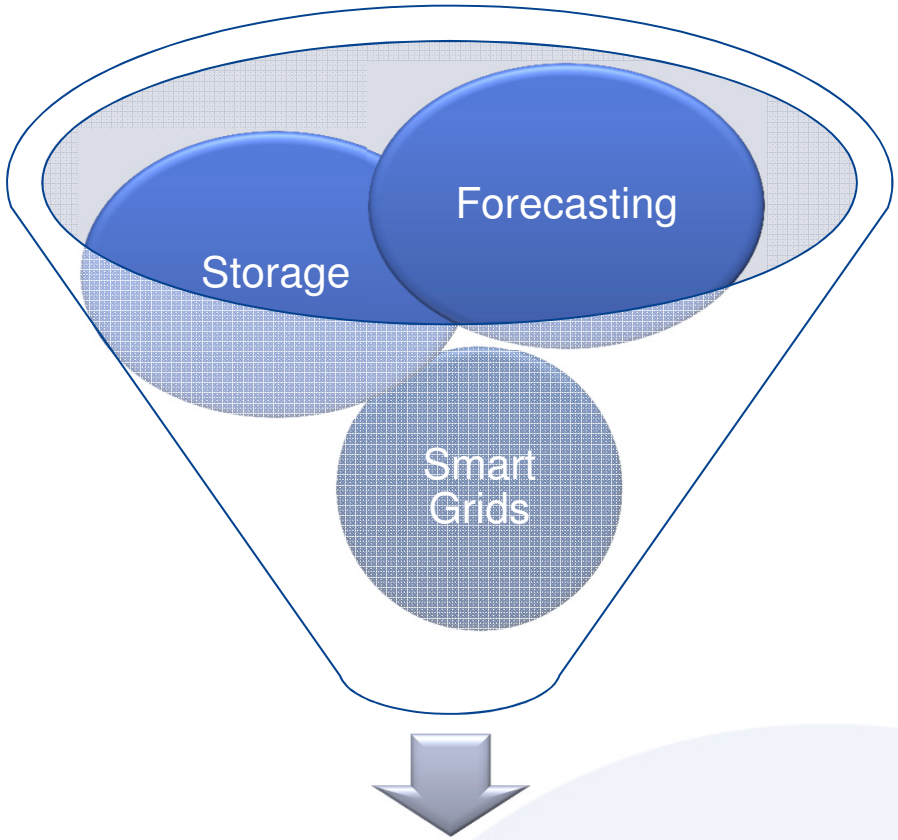
Some solutions…

- There are several challenges associated with renewable energy development. These challenges should be addressed via technology advancements and adjustments in policy and regulatory frameworks.
- Possible technological solutions include storage, grid development and demand-side management via smart grids and smart meters.
- However, these solutions have associated issues which will also need to be resolved.



Eliminating/Reducing the Issues Associated with Increased RE Penetration

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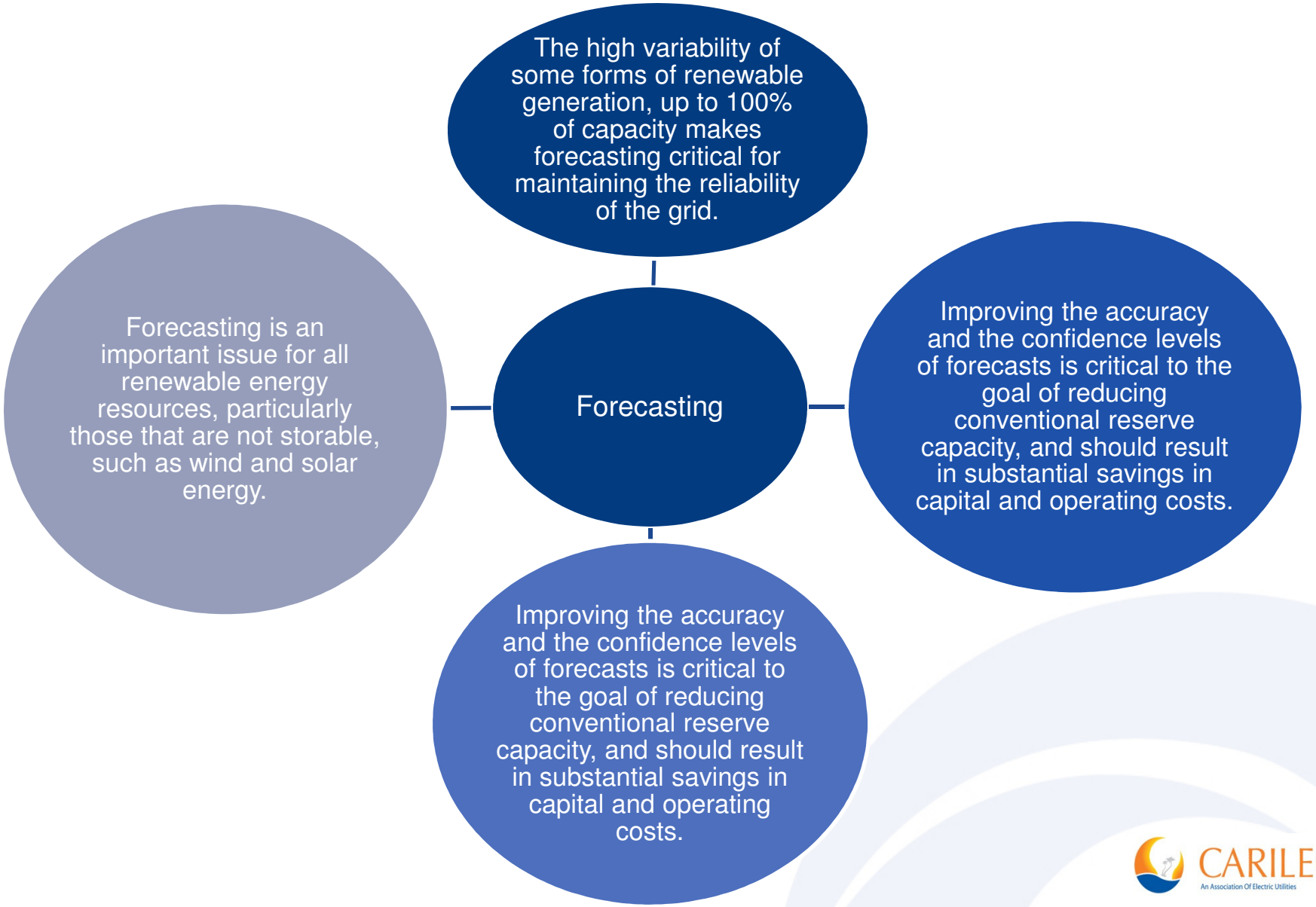
Some solutions: Forecasting



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Some Solutions: Forecasting

The Meteorological Organizations and/or private vendors should:

- Improve the accuracy of weather forecasts, in spatial and temporal resolution and on time scales from hours to days.
- In addition to accuracy, the confidence level of the forecasts must be improved to allow system operators to reduce reserve requirements and contingency measures to lower and more economical levels.

Forecast providers and/or RE systems operators, and regulatory agencies should:

- Agree on and develop uniform standards for preparing and delivering wind and power generation forecasts.
- Develop and codify operating procedures to respond to power generation forecasts.

  Develop, standardize and codify the criteria for contingencies, the response to up- and down-ramps in generation, and the response to large weather disturbances.

To be useful to the system operator, weather forecasts must be converted to forecasts of the power expected to be generated by the renewable resource. This is typically done with the assistance of a physical model, a statistical analysis process, an artificial intelligence-based learning system, or some combination of these techniques.

Some Solutions: Energy Storage

Energy Storage

- As renewable generation grows it will ultimately overwhelm the ability of conventional resources to compensate renewable variability, and require the capture of electricity generated by wind, solar and other renewables for later use.
- Storage technologies will have a role to play in bringing more flexibility to the system while cutting resource losses, as they allow surplus energy to be used later

Storage Options

- Transmission level energy storage options include pumped hydroelectric, compressed air electric storage, and flywheels.
- Distribution level options include: conventional batteries, electrochemical flow batteries, and superconducting magnetic energy storage (SMES).

Recommendation

- There needs to be the development of an overall strategy for energy storage in grid level applications that provides guidance to regulators to recognize the value that energy storage brings to both transmission and generation services to the grid

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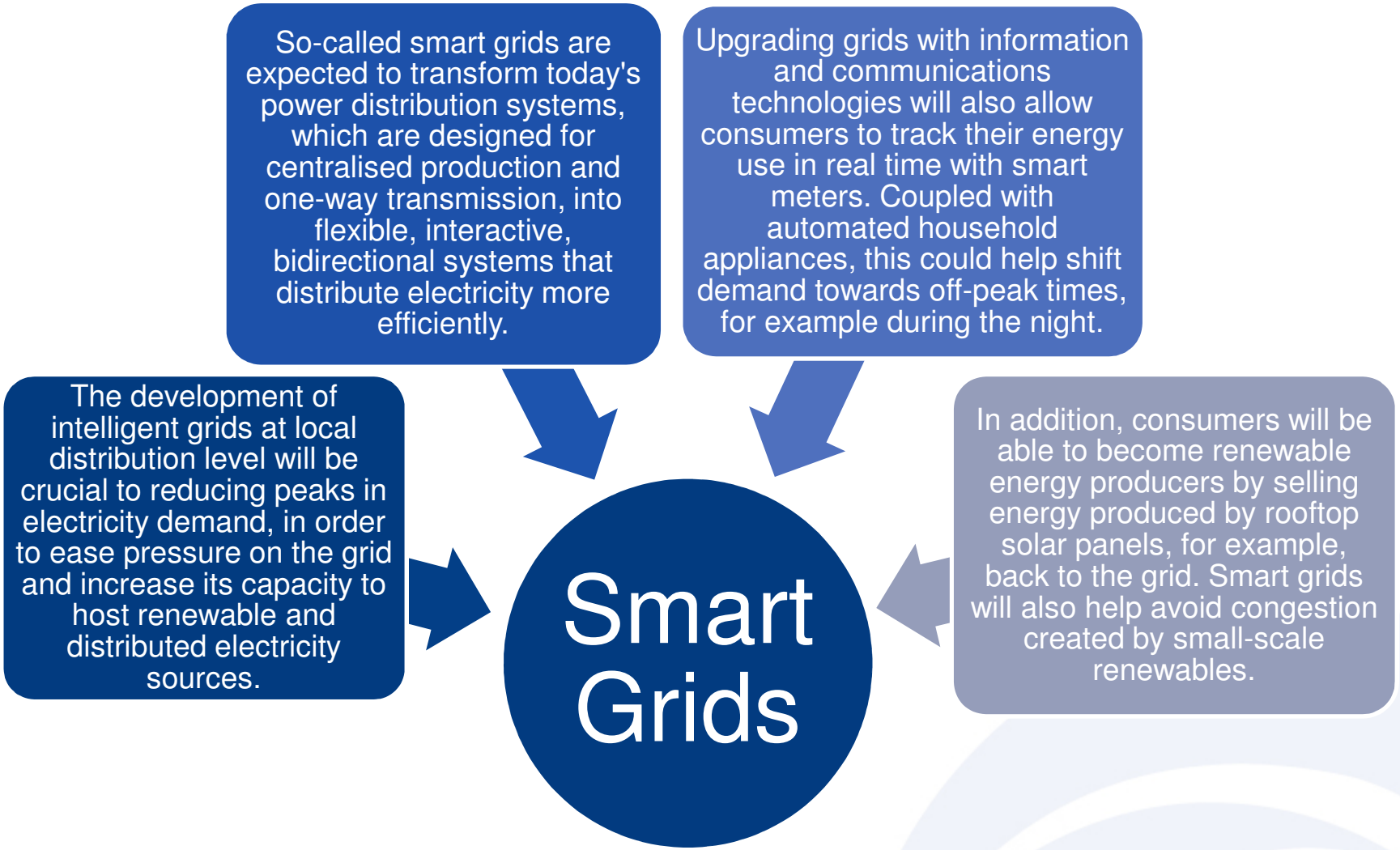
Some Solutions: Smart Grids



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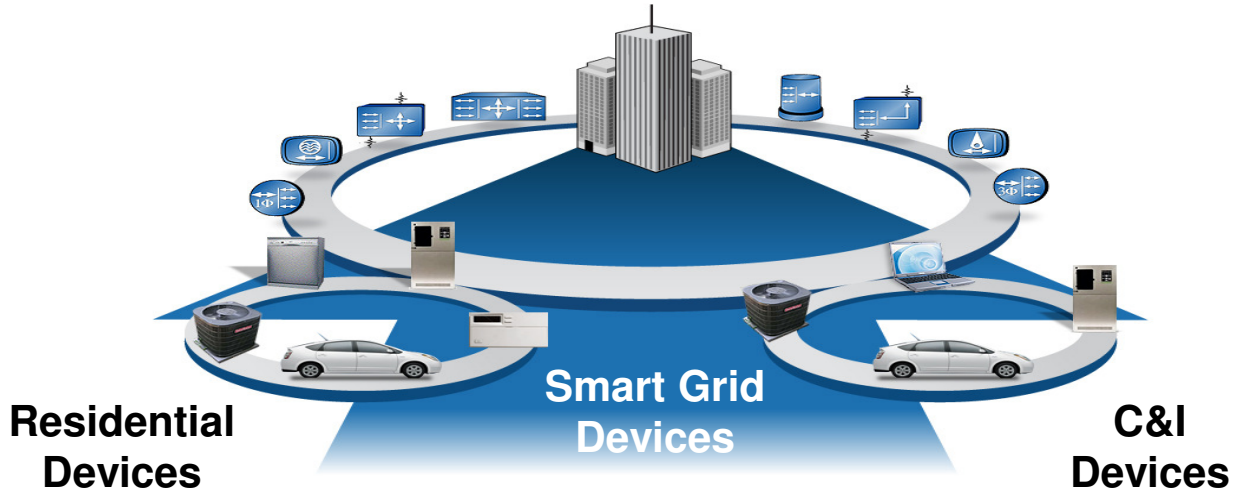
Smart Grids – Characteristics



- Plug and play: seamless integration of all people and devices that generate, distribute or use energy
- End user real time information and participation
- Allows diverse generation and storage options
- Automated payment through the value chain

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REGULATION… SHOULD BE BASED ON BEST-PRACTICE PRINCIPLES

Independence	Most important principle
Communication	Stakeholders should understand initiatives
Consultation	Stakeholders should be able to provide feedback
Consistency	Results in confidence
Predictability	Allow planning for future

Flexibility	Ability to evolve and improve
Capacity	High level of knowledge and expertise
Effectiveness	Monitor costs and benefits
Accountability	Responsibility and appeals
Transparency	Visible and fair processes

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Conclusion

Jamaica depend mainly on imported fossil fuels for electricity production while presenting a considerable potential in renewable energies.

- However, unlike hydro or geothermal energy sources that can account for the base load, intermittent renewable energy sources, such as wind and wave energy, have to tackle the need for storage.

CARILEC supports the integration of renewables within the grid.

- There is a need for greater coordination on policy, legislation
- The technical issues should be addressed in a manner that supports sustainable operations of the utilities.
- Advanced energy planning must be used to combine different intermittent and regular sources in order to match electricity demand and assure security of supply

So far the energy policy aiming to promote RE within the region have largely neglected to study the immediate and future technological feasibility of such programmes.

- However, this has serious implications on the cost of electricity supply systems and need to be considered alongside the dynamics of energy markets to allow capturing economic risks and benefits also in the long term.

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- THANK YOU
- ANY QUESTIONS/ COMMENTS?

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