USTDA Funded
Kenya Network Energy Storage Study

US-Africa Clean Energy Standards Program

Energy Storage Standards, Conformance and Technology Workshop

Nairobi, 24th May 2018

KENYA NETWORK ENERGY STORAGE STUDY

USTDA Funded Kenya Network Energy Storage Study:

USTDA Grant of $1.1m for Technical Assistance to Kenyan Grid Study for Energy Storage Assessment.

The analysis will identify and financially quantify the potential benefits of the systematic deployment of battery energy storage across the Kenyan grid.

And design an optimized network energy storage system (NESS) to deliver value added ancillary services to the Kenyan electricity system.

Grant Signing Ceremony with Ambassador Godec in Nairobi 27th April 2017

Partnership Announcement USTDA and Dr Randell Johnson (Acelerex, Inc) at National Press Club, Washington DC, 15th February 2017

Xago Africa and the Project Team

- Xago Africa is a developer of renewable energy and infrastructure projects supported by private funding which aims to support economic growth and sustainable industrial development in Africa
  - Established in Kenya in 2014, Xago Africa combines engineering and project management capabilities with a strong investor network
  - Currently developing the 40 MW Siaya Solar Power & Energy Storage Project near Lake Victoria which will help to alleviate power shortages in Western Kenya
  - And a 30 MW solar + energy storage project in Zimbabwe
  - While also promoting battery energy storage systems to substantially enhance the efficiency and stability of national electricity systems and to accelerate the integration of renewable energy sources

- Xago Africa (the grantee) secured the USTDA grant for the Kenya Network Energy Storage Study with California battery technology company Primus Power as prime contractor and Boston based Acelerex in the role of Technical Assistance provider
  - **Primus Power** offers long-duration, fade-free energy storage solutions (zinc bromide flow battery technology) for the smart grid
  - **Acelerex** is a global data analytics and software company active in electricity sectors, renewables, grid modelling and energy storage management systems

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About Acelerex

- Recognized leader in **ESS optimization**
- Nodal, **real-time** power market analysis
- Tested, **proprietary energy management tools**
- Propriety **Software**
- Use smart contracts to **cut transaction costs**
- **Super computing** via the cloud
- Experienced **due diligence capability**
- Located at **Cambridge Innovation Center** (CIC), Cambridge

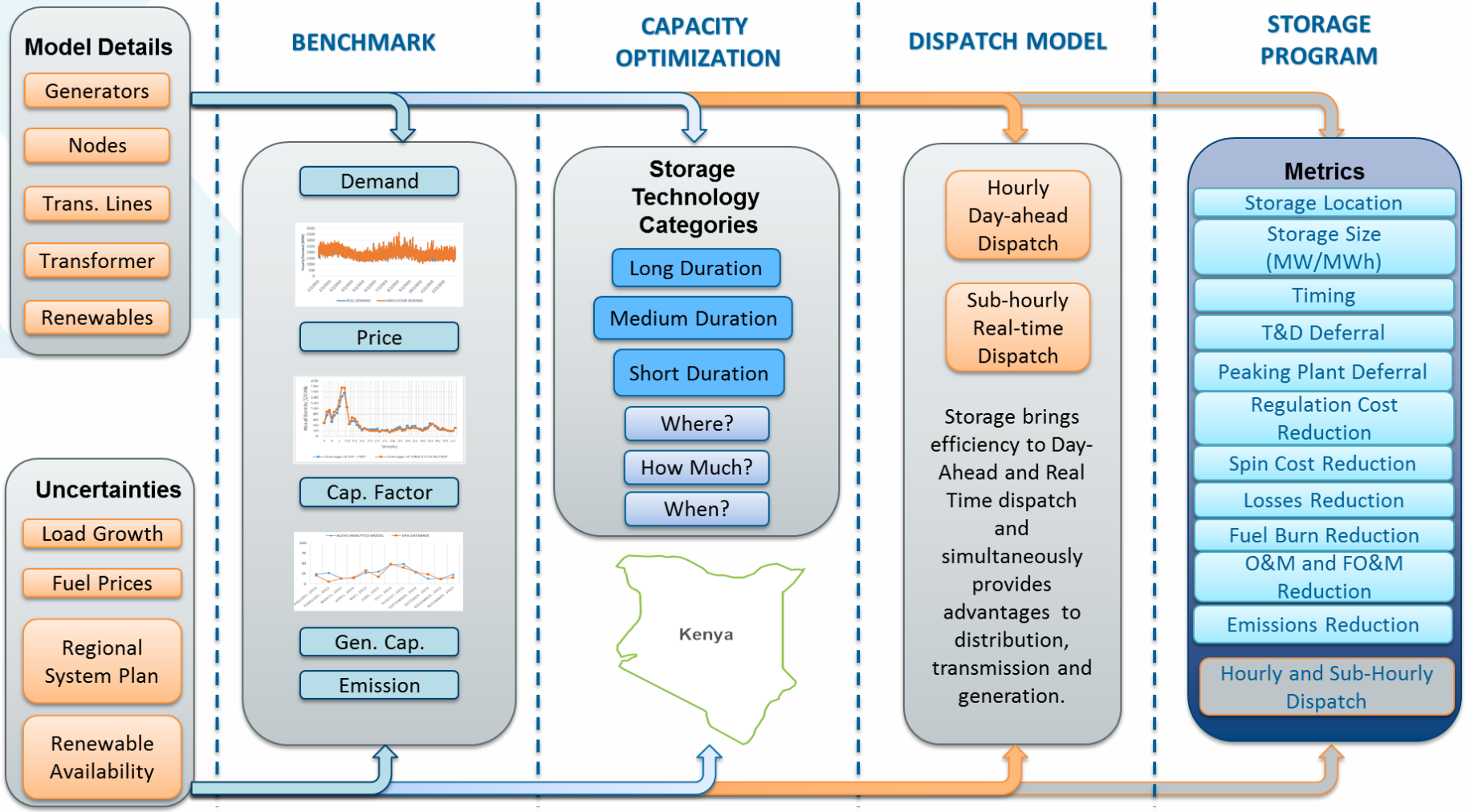
Core Capabilities

- ☑ Energy Storage System Design
- ☑ High-Performance Computing
- ☑ Stacked Services
- ☑ Real-time Control System Software
- ☑ Blockchain and Smart Contract
- ☑ Asset Optimization
- ☑ Remote Operations
- ☑ Portfolio mgmt.
- ☑ Services

Technical Assistance - Terms of Reference

- Task 1: Kick-off Meeting and Information Gathering
- Task 2: Stakeholder Engagement
- Task 3: Technical Analysis
- Task 4: Economic Analysis
- Task 5: Financial Analysis
- Task 6: Preliminary Environmental Impact Assessment
- Task 7: Legal, Regulatory and Institutional Review
- Task 8: Development Impact Assessment
- Task 9: US Sources of Supply
- Task 10: Implementation Plan
- Task 11: Tender Documents Preparation and Owner's Engineer Tasks
- Task 12: Final Report

Methodology of Energy Storage Study in Grid Planning



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Stakeholder Engagement Programme

- Primary objective of the Stakeholder Engagement Programme is to seek input from and educate Project Stakeholders in government, the power utilities, industrial and consumer groups
  - Capabilities and benefits of energy storage solutions
  - Technical aspects of integrating energy storage systems with the other systems in the power grid, and
  - Policies and practices that can support the adoption of energy storage technologies in Kenya
- And engage key stakeholders in the network storage study through an Advisory Committee and Working Groups – representatives from MOE, ERC, Kenya Power, KETRACO, KenGen
  - Data gathering and analytics
  - Network system modelling
  - Scenario building and optimization
  - Study results and recommendations

Key Stakeholders and Advisors

USTDA
U.S. TRADE AND DEVELOPMENT AGENCY

KETRACO
Kenya Electricity Transmission Co. Ltd.
"Building a World Class National Grid"

POWER AFRICA

Kenya Power

erc
Energy Regulatory Commission

REPUBLIC OF KENYA
MINISTRY OF ENERGY AND PETROLEUM

KenGen

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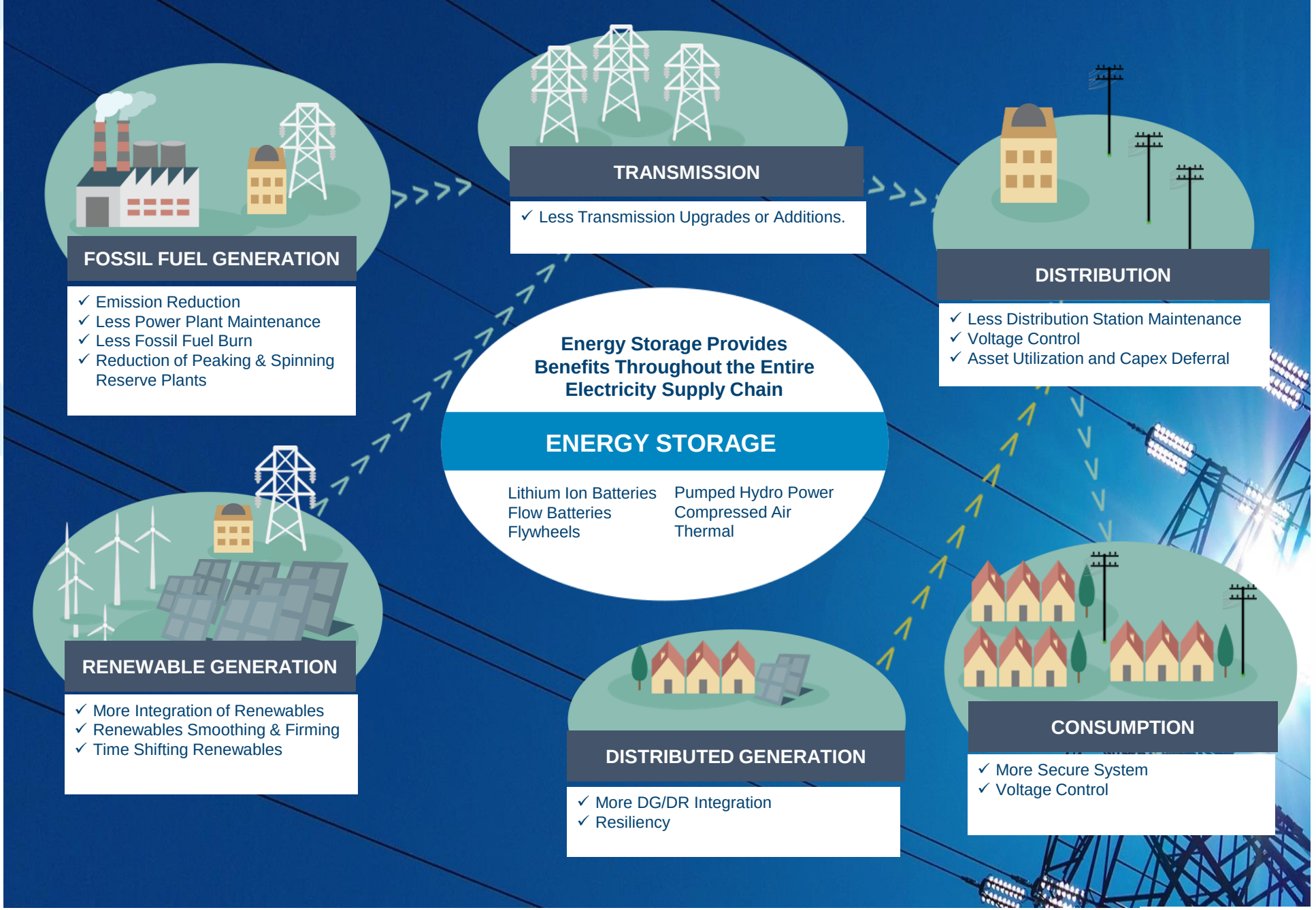
Potential Benefits of Network Energy Storage

1. Increase efficiency and stability of national grid
2. Optimise the grid by storing and releasing energy when and where it is needed thereby reducing energy waste
3. Defer capital expenditure on the grid by utilizing existing transmission and distribution capacity more efficiently during off-peak hours (**T&D Deferral**)
4. Defer capital expenditure on generating capacity by replacing peaking plants and spinning reserve with battery storage (**Peak Shaving** and **Spinning Reserve**)
5. Deliver **Ancillary Services**
   - **Frequency Regulation**
   - **Voltage Support**
   - **Peak Shaving**
   - **Spinning Reserve**
   - **Black Start**
6. Provide pathway to expand **Renewables Integration** by
   - Storing energy locally at solar or wind farms when it cannot be utilized by the grid
   - Discharging that energy to the grid during peak periods
   - Firming and smoothing variable generation output
7. Reduce reliance on expensive fossil fuels



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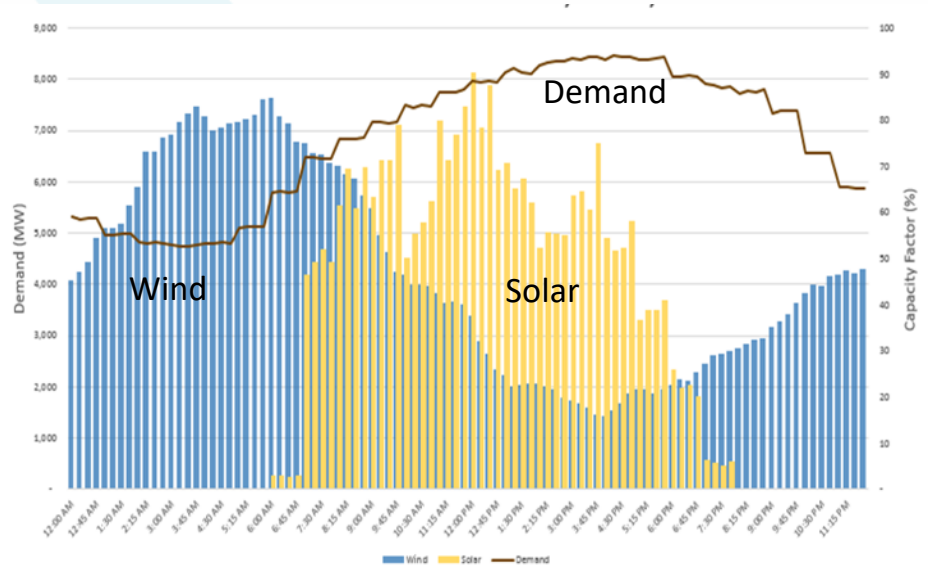
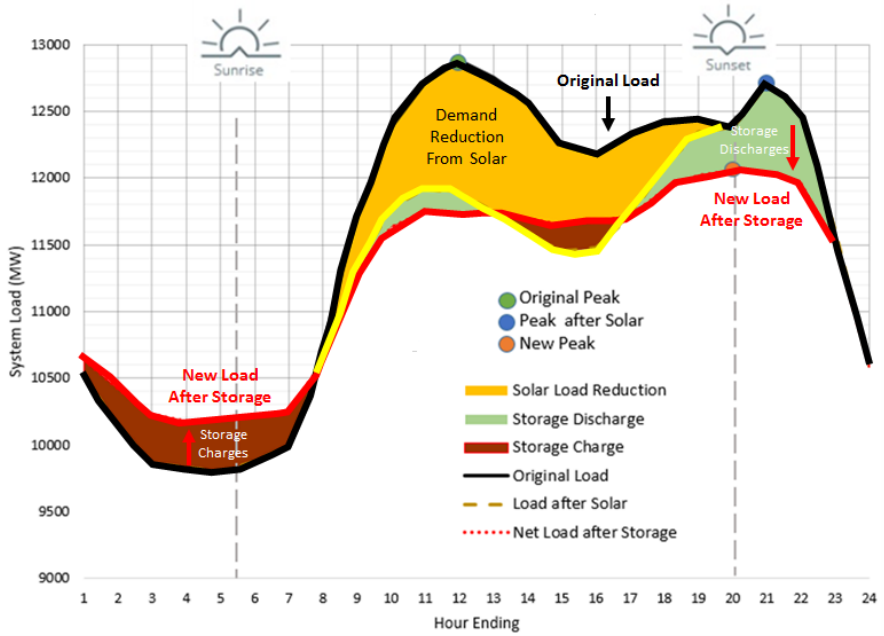
Time Shift of Renewables and Peak Reduction



Net Load Profile



- Renewables help to reduce system peak and storage can provide additional peak reduction by shifting energy from non-peak to peak
- Relieves distribution constraints

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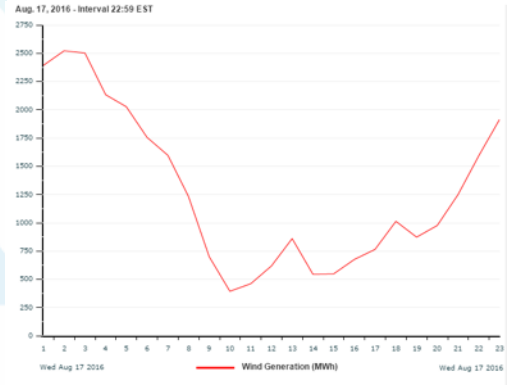
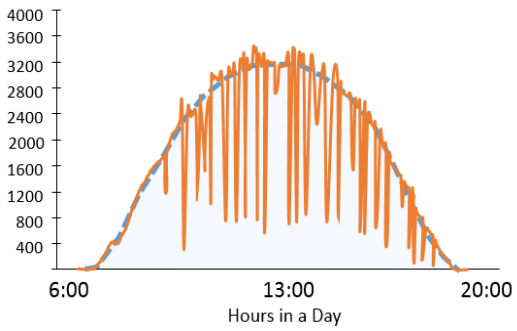
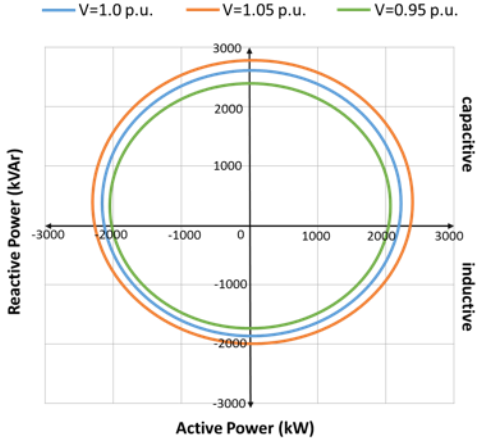
Solar/Wind Shifting & Ramp Control

Wind Ramp Control Solar Ramp Control 4 Quadrant Power Control







Renewables shifting or ramping control of the generators reduces solar curtailment and resource intermittency caused by weather, etc

Higher quality power through four quadrant active power and reactive power control to help **eliminate voltage violations and solve power flow non-convergence**

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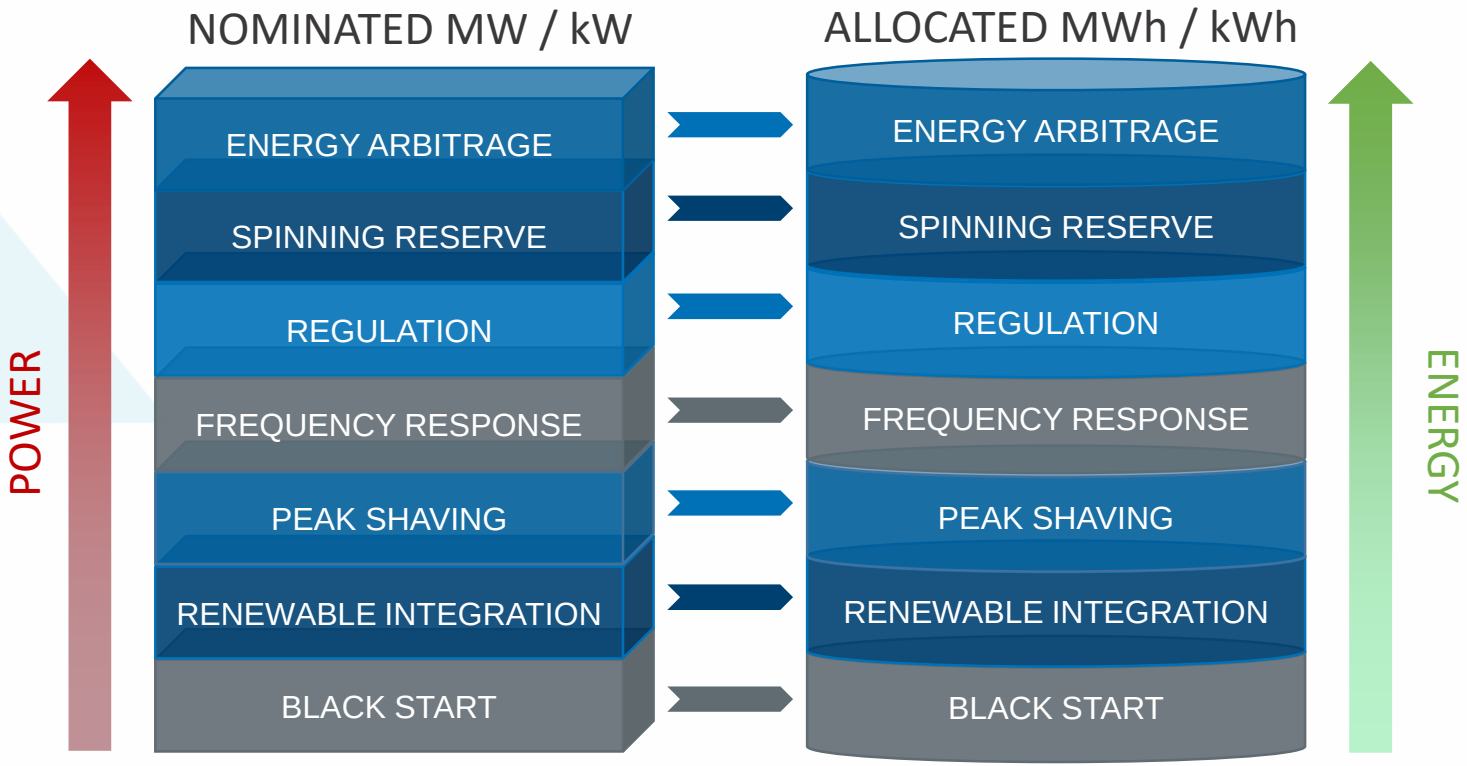
Stacked Services



Stacked Services can be optimized to:

- Minimize Cost
- Maximize Revenue
- Minimize Load Peak
- Others

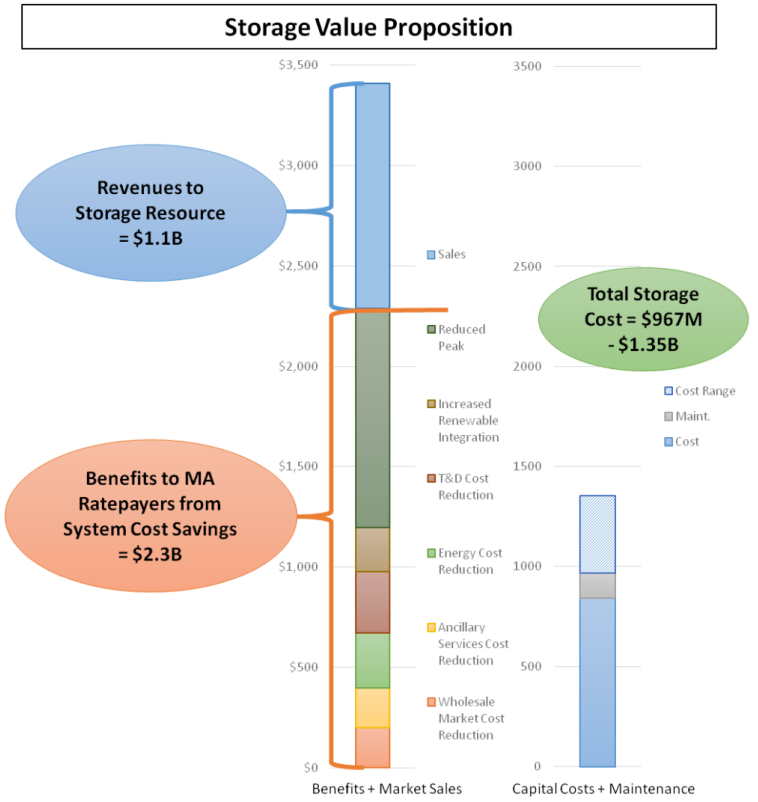
Implication of bidding of stacked services

- Increase ROI of ESS
- Improve micro-grid operation
- Stabilize energy markets
- Optimize ES utilization

MA State of Charge Report Benefits

In the study Massachusetts "State of Charge" report, 78 sites were selected for energy storage deployment through both the production cost optimization model and the capacity optimization model. These sites accounted for **1,766 MW/2,125 MWh** of energy storage, which would result in up to **$2.3 billion in total benefits**.

Benefit Description	Ratepayer Savings
Energy Cost Reduction Energy storage uses lower cost energy stored at off-peak to replace the use of higher cost peak generation: • reduced peak prices • reduced overall average energy price	$275M
Reduced Peak Capacity Energy storage can provide peaking capacity to: • defer the capital costs peaker plants • reduce cost in the capacity market	$1093M
Ancillary Services Cost Reduction Energy storage would reduce the overall costs of ancillary services required by the grid system through: • frequency regulation • spinning reserve • voltage stabilization	$200M
Wholesale Market Cost Reduction Energy storage provides system flexibility, reducing the need to ramp generators up and down and resulting in: • less wear and tear • reduced start up and shut down costs • reduced GHG emissions (lower compliance cost)	$197M
T&D Cost Reduction Energy storage: • reduces the losses and maintenance of system • provides reactive power support • increases resilience • defers investment	$305M
Integrating Distributed Renewable Generation Cost Reduction Energy storage reduces cost in integrating distributed renewable energy by: • addressing reverse power flow at substations • avoiding feeder upgrades at substations	$219M
Total System Benefits	$2,288M



NYSERDA Energy Storage Study Roadmap

- **Initial/Partial Base Case Benefits and Costs under a Resource Cost-Style Lifetime BCA**

2025 (1,500 MW, 7,267 MWh)	
Model Benefits	**NPV in 2017 M$**
Ancillary Services	$75
Capacity Value	$516
Distribution Savings	$892
FOM	$81
Gen Cost Savings	$118
Benefits	$1,634
Costs	$1,104
Net Benefits	**$530**

2025 (1,988 MW, 9,578 MWh)	
Model Benefits	**NPV in 2017 M$**
Ancillary Services	$99
Capacity Value	$588
Distribution Savings	$1,116
FOM	$125
Gen Cost Savings	$146
Benefit	$2,074
Costs	$1,463
Net Benefits	**$611**

2030 (2,795 MW, 12,557 MWh)	
Model Benefits	**NPV in 2017 M$**
Ancillary Services	$140
Capacity Value	$732
Distribution Savings	$1,533
FOM	$214
Gen Cost Savings	$199
Benefit	$2,818
Costs	$1,766
Net Benefits	**$1,052**

Note: Does not include quantification of any emissions benefits including carbon, SOx, NOx, and health impacts. Transmission benefits from congestion relief are included in lower LBMPs within “Generation Cost Savings.” Examining any potential for avoided transmission infrastructure was beyond the scope of this study and not considered in the model.

Powering the Future with Renewables and Energy Storage

- 600 Million Africans without Electricity
- Government Plans on Connecting Households to Electricity
  - Last Mile Connectivity
  - Distributed Generation Systems
- Economic Development is supported by Reliable Cost Effective Power Sector
- Reduced Dependency on Fossil Fuels
- This Generation can Fully Exploit Renewables with Energy Storage