Standards and Evaluation Methods for New Proposed Integrated Systems

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Abstract

This report details methods and guidelines for evaluating new integrated systems for facilities that will incorporate high levels of variable renewable energy. Since these facilities aim to incorporate greater renewable energy in their electric infrastructure, this report describes why new and innovative systems are necessary to accomplish this while retaining reliability, robustness, and efficiency despite the additional challenges of variability. It goes through the process taken to create standards based on system qualities related to all three of these characteristics and details any evaluation steps necessary to determine whether a proposed system meets each standard. Ultimately, it creates measurable standards where possible and specifies where additional information and data are needed to make a standard measurable and therefore usable to evaluate proposed systems. It specifies the variables of a proposed system that must be known in order to conduct the evaluation that this report lays out. Through all of these aspects, the report is a comprehensive guideline for how to evaluate newly-proposed integrated systems and ensure they perform as needed.

Introduction

Background:

We need to implement more clean, renewable energy in facilities to reduce their negative environmental impact while maintaining performance, reliability, robustness and efficiency. While this is important, additional renewable energy sources create additional challenges within the system that must be managed. Sources such as solar, wind, and hydroelectric power all create system variability due to the uncontrolled input power, while fossil fuel sources have a controllable input that can be matched to load. Challenges such as these must be addressed by creating innovative integrated systems with mechanisms to manage variability and ensure continuous service.

This is a significant transition period where new types of integrated systems must be conceptualized, constructed, and evaluated for use in existing facilities. Creating systems with high renewable energy implementation that are reliable and robust require creative integrated solutions to account for the facility's relatively small system size, disconnect from the larger electrical grid, and more stringent service availability and general reliability requirements compared to residential applications. Due to the isolation, they will experience higher resource variability. These integrated systems will likely have several power generation methods and supporting storage methods to control varied input power and reduce variability. Implementation of high variable renewable energy integrated electric systems is a new, necessary challenge that does not yet have established standards or evaluation methods to determine feasibility and compatibility with the needs of the facilities these systems will be implemented in. This report provides a new solution that can guide this implementation.

Problems to Address:

- What criteria and standards must new integrated systems adhere to in order to ensure reliability and robustness?
  - Measurable standards based on research into existing system capabilities
  - Measurable standards may differ based on known variables of proposed integrated systems
- What methods should we use to evaluate these new proposed systems and ensure they meet each defined criteria?
  - Software
  - Experimental procedures
  - Mathematical models

Impact:

This work provides a framework for which to evaluate new proposed integrated systems. It will ensure that all proposed electric grid projects with high-VRE inclusion are held to universal standards and evaluation procedures. Maintaining performance is critical in the transition to sustainable integrated systems, so these standards will keep new integrated systems at the same or greater reliability, robustness, and efficiency levels than current systems. New integrated systems will reduce carbon footprint without compromising function or performance if they follow these guidelines.

Objectives

- Identify all system aspects and performance metrics related to both reliability and robustness of an electric system
- Create a standard for each metric based on existing standards and existing system capabilities while taking into account the additional challenges of implementing greater VRE in the integrated system
- Determine methods to evaluate proposed integrated systems to ensure they meet standards

Hypothesis and Technical Approach

Hypothesis:

If we establish effective standards tailored to high-VRE integrated systems, the reliability and robustness of these implemented systems will meet or exceed that of current systems despite the additional challenges of new integrated systems.

Approach:

1. Brainstorm

Look at various research avenues and evaluate their potential to fulfill CERL needs. Choose an avenue and conceptualize an approach.

2. Define reliability and robustness characteristics

Use existing knowledge and sources on reliability and robustness in electrical systems to create a set of system characteristics that encapsulate both reliability and robustness. These will be the characteristics that must have measurable standards and be evaluated in new integrated systems.

3. Determine needed conditions and variables, parameters of proposed integrated systems

Each proposed integrated system should have several known or defined characteristics in order to be evaluated with the methods I am creating, so this step lays out these characteristics. It also gives an overview of the system's evaluated parameters.

4. Conduct research and comparative analysis into existing high-VRE electric systems

Current isolated high-VRE electric systems can show me a lot in terms of current system capabilities and the reliability and robustness potential of a high-VRE system, based on the variability of the system among other factors. This step encompasses in-depth research on these current systems and a comparative analysis that can be used to set standards for newly developed and proposed systems.

5. Create criteria

Using results from the analysis of existing systems, existing standards and differences in high-VRE systems, create measurable criteria for each of the evaluated parameters of new integrated systems. These criteria may be universal to all proposed systems or dependent on known system characteristics.

6. Determine methods of evaluation for new integrated systems

New integrated systems must be evaluated for these criteria, so this section will determine which methods of evaluation to use to evaluate these systems.

7. Create recommendations and next steps to expand on work

In the event of any incomplete criteria or testing methods, this section creates recommendations on how to continue this work and create a complete set of guidelines for evaluation of integrated systems.

8. Build presentation

9. Write final report

<u>Schedule & Milestones:</u>

Week	2-21	2-28	3-7	3-14	3-21	3-28	4-4	4-11	4-18	4-25	5-2	5-9	5-16	5-23	5-30	6-6
Task 1	■	■	■	■												
Task 2				■	■	■	■									
Task 3							■									
Task 4								■	■	■						
Task 5						■	■	■	■	■	■	■				
Task 6										■	■	■	■	■		
Task 7														■	■	■
Task 8	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Task 9															■	■

Findings

Variable Renewable Energy: VRE is the acronym for Variable Renewable Energy. High VRE penetration is considered to be a minimum of 50% annual energy provided by the system with the capability to provide up to 100% instantaneous power (Kroposki 1). Ideally, we want to implement integrated systems with high percentages of VRE.

Curtailment: An intentional shut-off of power generation systems to control input power. In the event that input power exceeds load enough to overwhelm storage and other input power control systems, curtailment may be necessary. Several factors influence the decision to curtail power (Bird 16). Particularly in wind applications, one of the greatest reasons for curtailment is transmission constraints. When the development of additional renewable energy sources outpaces the development of transmission lines to transport the generated energy, curtailment is implemented to protect this transmission. System balancing may also be a challenge that requires curtailment in the scenario that input power exceeds load, storage sources, and other power routes. Voltage, interconnection, and stability issues are also prevalent causes of curtailment. Defining curtailment standards for new integrated systems based on these factors may ensure that it is implemented properly to ensure reliability.

NRMSE: NRMSE, or Normalized Root Mean Square Error, is a measure of error that can be used to determine the accuracy of a forecasting system (Zhang 61). This calculation can be used to evaluate the accuracy of any forecasting method given that you know the predicted power input and the actual power input after the time horizon has passed. The lower the NRMSE, the less error between predicted and actual power input and the more accurate the system is.

Formulas 1 and 2:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y})^2}{n}} \qquad NRMSE = \frac{RMSE}{\bar{y}}$$

Here is an example of several forecasting methods evaluated for accuracy using NRMSE (Zhang 61).

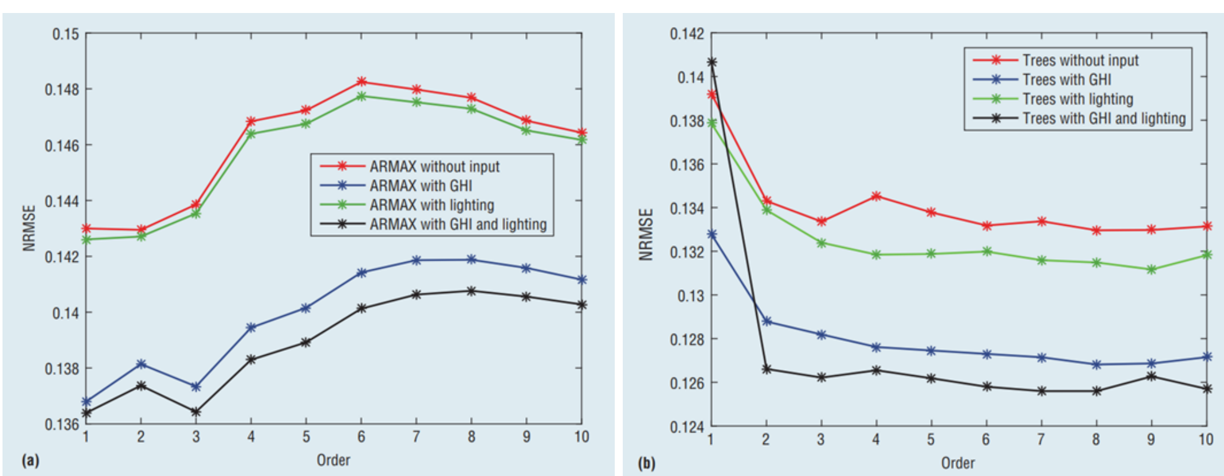

Figure 1: NRMSE of Several Forecasting Systems based on Order

Good forecasting accuracy leads to a reduction in voltage violations, as shown in Figure 2 (Zhang 63).

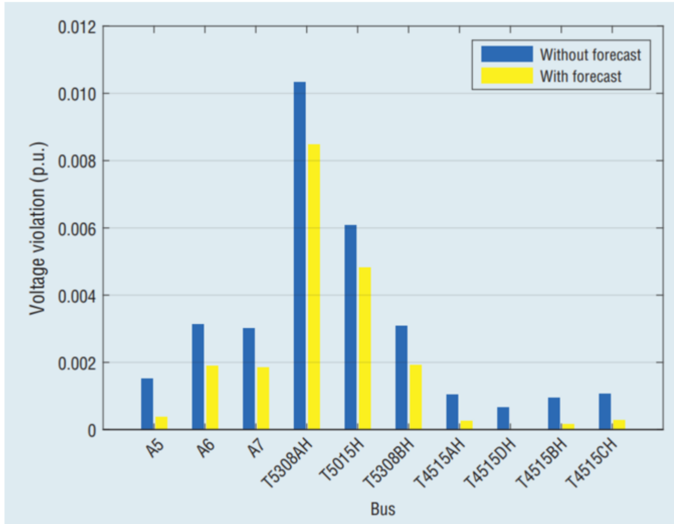

Figure 2: Voltage Violation With vs Without Forecasting for Different Systems

<u>Admittance</u>: Describes the ease of electrical flow by how much current is admitted through a circuit (Cho 5). This is the inverse of impedance. The formulas below describe the calculation of admittance, which can be used in evaluation of proposed integrated systems. The second function may vary depending on the control system implemented.

Formulas 3 and 4: Converter Admittance

$$I_g / V_{PCC} \qquad Y_{con} = \frac{Y_{g1} - G_{PWM} Y_c}{1 + G_{op}}$$

<u>Harmonic stability</u>: Critical to the proper function and reliability of an electric system. There are several methods (Cho 2) to evaluate the harmonic stability of a system.

- Stability Analysis in Grid interconnection
  - Identifies components to be studied and details a practical process for integrating new converter-interfaced generators into a grid with existing CIGs (converter-interfaced generators)
  - Detailed EMT (electromagnetic transient) simulations are conducted for various connection scenarios between these components to validate the accuracy of stability assessment
  - This proposed approach enables grid planners to identify critical design parameters for integrating new CIGs and ensuring continued reliability
- State-Space Analysis
  - Well-known method for the analysis of converter stability
  - Includes the control dynamics of power electronic converters
- Harmonic issue detection and mitigation solutions
  - Evaluates converters' interaction with harmonic impedance from passive grid elements – cables, transformers, harmonic filters
- Impedance-based stability analysis for DC and AC systems

    - Converter admittance formula used in this analysis, higher admittance points to stability
    - Equivalent impedance calculated using admittance for multiple CIGs (eqn 21)
- Larger distance between CIGs causes lower stability of the system

Discussion

Known Integrated System Parameters and Control Conditions:

In order to evaluate proposed integrated systems, certain characteristics of these systems must be known or defined so they can be applied in any model to evaluate its compatibility to criteria. These are the system characteristics that must be defined for each proposed system.

- Each production method involved and the percentage of total system size that it occupies
- System size (Watts) and load (Watts) based on the facility or location that the proposed system will be implemented at
    - If possible, daily/yearly load trends should be provided along with average, peak, and minimum load
- Each storage system involved and its capacity (Watts or annual Watt-hours)
- Area occupied (acres or m^2)
- Isolated or electric grid-connected

Each proposed integrated system will go through a series of evaluations, many comparative. It will be valuable to evaluate newly-conceptualized integrated systems as well as simple, well-known energy systems as a control. This provides a comparison of new integrated system results with the expected results of common current systems. These are the common systems to evaluate along with new integrated systems in order to generate control data.

- Single production-method systems such as purely solar, wind, hydro, or another VRE source
- Diesel or fossil fuel-only systems

Evaluated Parameters of Integrated Systems:

Effective integrated energy systems are proficient in several critical parameters. These parameters are unknown and dependent on several system qualities, but must be evaluated in proposed integrated systems to determine system effectiveness.

- Component compatibility in design and criteria (Cho 2) (DoD 3)
- Total system cost
- Compliance with energy reduction standards (DoD 8)
- Reliability
- Robustness
- Efficiency

The final 3 parameters require an in-depth analysis. Each has an explained definition, criteria, and procedures for evaluation within proposed integrated systems in these further sections.

Current High-VRE Systems Comparison:

This figure and the table below summarize a comparison between the critical qualities of several existing systems that are highly isolated and high-VRE. This data provides an understanding of the capabilities of current systems; a benchmark to construct models and create measurable standards that are ambitious yet reasonable based on system needs as well as current system capabilities. This is a tool I use in several of the following sections to define quantitative standards.

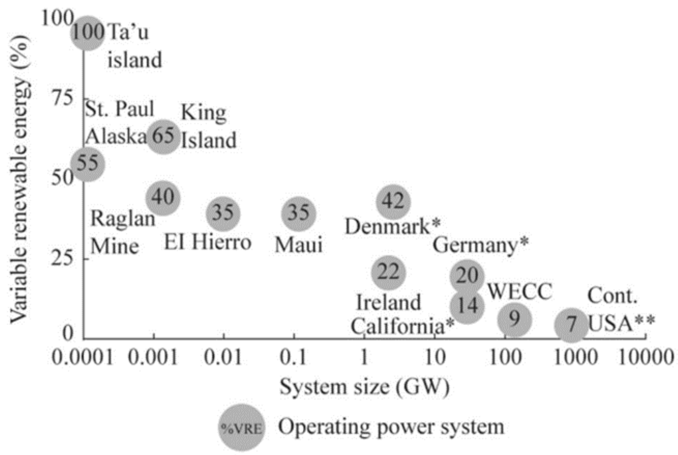

Figure 3: System Size vs VRE % Plot of Current Systems ()

Table 1: Comparative Characteristics of Current High-VRE Isolated Systems

	System Specifications									Reliability Factors	
System / Location	System Size (MW)	System Distribution			VRE %	Average Load (MW)	Peak Load (MW)	Storage Type(s)	Storage Capacity (kW)	Service Availability (%)	Failures
Island of Maui	1019	1019 MW Solar			35	80	200			99.98	
King Island	6	470 kW Solar	2.45 MW Wind	Diesel	65	1.37	2.5	Battery, Flywheels, dynamic resistors	4500 + 1 MVA		
St. Paul, Alaska	1.2	900 kW Wind	300 kW Diesel		55	0.07		Flywheel			
Kodiak Island, Alaska	28	20% Wind	80% Hydro		95	18	25 (min 11)	Battery	3000		
Raglan Mine, Northern Canada	4.6	3 MW Wind	1.6 MW Diesel		40	1.4		200 kW flywheel, 200 kW Li-Ion battery, 200 kW PEM fuel cell	600	97.3	
El Hierro, Canary Islands	7	7 MW Wind			35	4	7.5	Pump hydro storage	7200 MWh for 100% wind system		February 18th and 19th, 18-month test
Ireland					22	5500	6500				
Flinders Island	3	200 kW Solar	900 kW Wind	Diesel	60	0.765	1.3	Battery, flywheel, dynamic resistor	2250 + 850 kVA		
Ta'u Island, American Samoa	1.4	1.4 MW PV Solar			100	0.08		6 MWh battery			
Coober Pedy	3.9	1 MW Solar	4 MW Wind	Diesel	70	1.48	3		4500 + 1.7 MVA		
Rottnest Island	1.2	600 kW Solar	600 kW Wind	Diesel	45	0.57	1.1				
CAISO		0.4 GW Solar	2.8 GW Wind		10.9	34246.6					
EEX		30.8 GW Solar	30.7 GW Wind		26.5						
IESO	38079	1.5 GW Wind			24.7	15278.5	22986				

Reliability:

System Reliability Characteristics:

- Service availability / continuity of energy provided: The percentage of time during a specified period that a system is operating. Failures and downtime contribute to non-operational time and lower the service availability.

- Production method diversity: The more energy input sources contributing to a system, the lower the variability of the system. Systems with lower variability are more consistent, predictable, and therefore reliable.
- Accurate short-term and long-term load and input power forecasting: Accurate forecasting improves a system's ability to respond to load and input power changes, reducing voltage violations and decreasing chance of failure.
- Quick and accurate response to power input, load changes, forecasting: The quicker a system can perform ramping (Kroposki 3), curtailment, and dispatch changes between load and storage based on short-term forecast results, the lower the chance of failure and/or voltage violation and the greater the reliability.
- Compatible harmonics and harmonic stability between components
    - Generators and inverters must be compatible
    - Wind and solar source inverter design must be compatible with electric grid (Kroposki 2) to integrate with other forms of power generation
    - Higher converter admittance is ideal (Cho 5)
- The ability to generate synthetic inertia that mimics synchronous generators can improve reliability (Kroposki 2)
- System size: Larger systems have higher stability and greater reliability
- Adequate energy or power storage capacity to account for variable power input: The greater the storage capacity, the lower the chance of stored energy/power running out in the event of low production or high load and causing an outage.
    - A storage capacity measurable requirement for reliability will depend on variability, which is determined by system size, area covered, and resource availability
    - The ideal and most reliable type of storage depends on several factors including type of integrated system, thermal response, cost, uptime, and capacity per unit of area/space taken.
- Availability of the natural resource(s) that provide input power: This varies based on geographic location and is relevant to solar, wind, and other VRE sources. High and consistent availability means lower variability and higher reliability. Lower system size is needed relative to load to maintain reliability at low variability, and systems spread out over a wider area have lower variability. Spread-out systems do have additional cost implications, however, and more voltage loss due to long-distance wiring.
    - "As you spread the VRE [variable renewable energy] across an area, there is a marked decline in the system-wide variability." (Kroposki 3)

Standards and Criteria:

The minimum service availability percentage for the system must meet or exceed current system standards for military installations or similar applications. Alternatively, the system must experience no outages per a specified time period in a system trial (Independent 5).

The system must have high VRE penetration, defined as a minimum of 50% of the annual energy provided by the system with capability to provide up to 100% instantaneous power (Kroposki 1).

System response time and ramping time must have a maximum standard that meets or is below the standard for existing systems.

Curtailment must occur when input power reaches a certain percentage (<100%) of combined load and storage capacity to ensure a balanced system. Other factors such as transmission lines, voltage, interconnections, and stability may also impact curtailment as shown by my Findings section. Assuming adequate capacity in interconnections and transmission, high enough allowable voltage and high stability, only system balancing has to be considered in a curtailment decision. Whether or not these other factors have to be considered depends on the individual integrated system under evaluation.

The minimum average input power and system size needed to ensure reliability cannot fall below a percentage of average load. This percentage will be >100% and depend on variability of the system. Variability can be roughly measured with the difference between peak and average input power, as well as peak and average load.

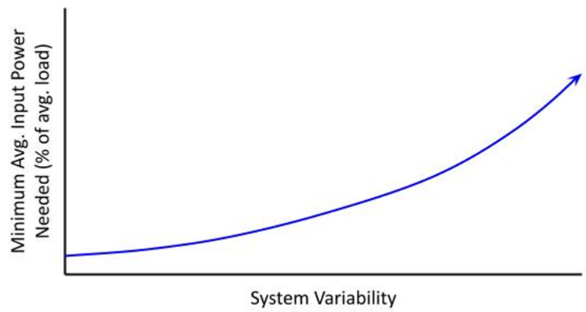

Figure 4: Expected Trend of Minimum Average Input Power Needed as a Ratio of Average Load

Short-term forecasting must not exceed a specified maximum NRMSE as calculated by Formulas 1 and 2 in the Findings section. The lowest NRMSE a system can reach depends on length of the time horizon, or period of time forecasted ahead, chosen for the integrated system. An NRMSE maximum standard can be developed based on current system capability shown by existing data (Zhang 62).

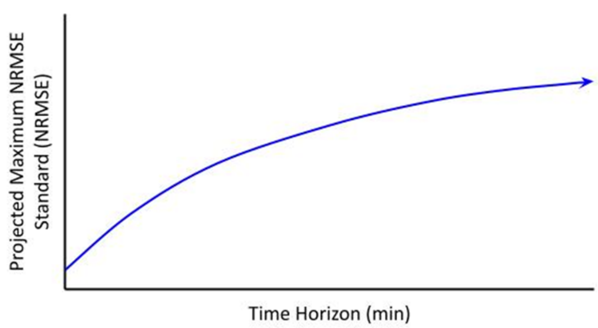

Figure 5: Projected Trend in Current System NRMSE Values and NRMSE Maximum Standard as Time Horizon Changes

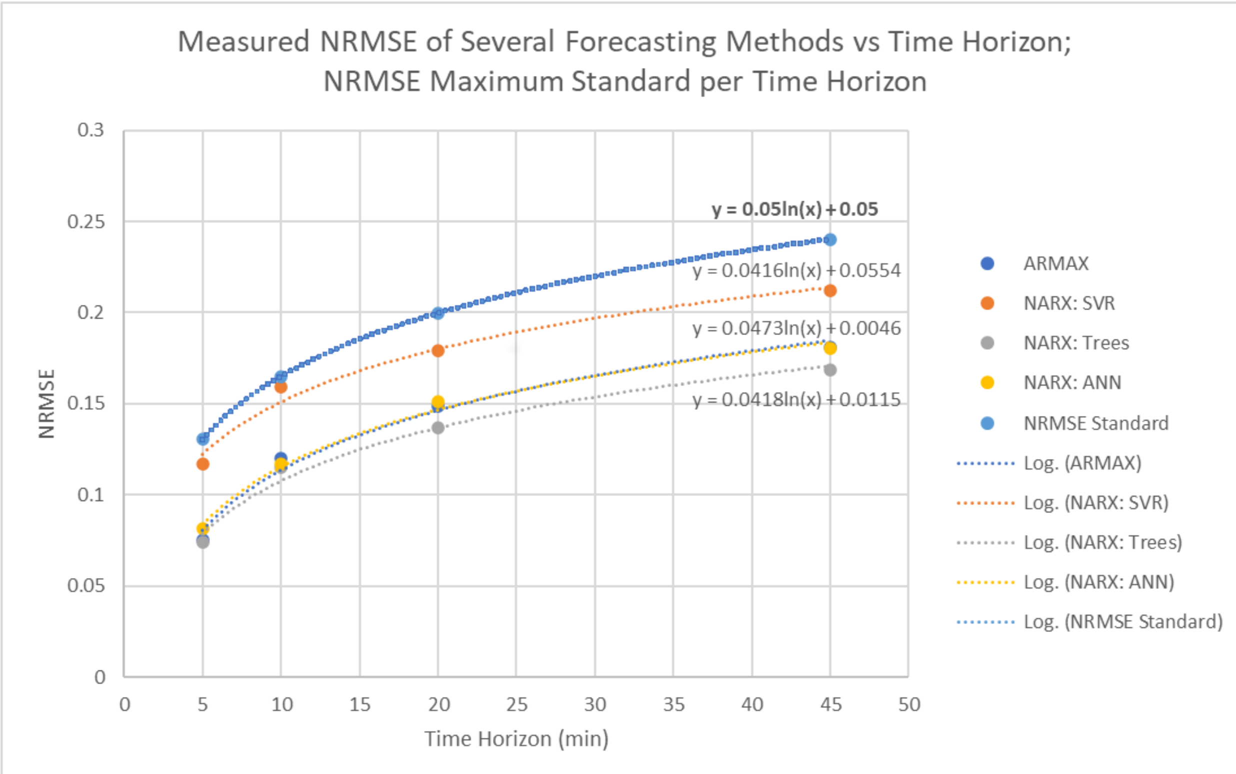

Figure 6

This plot of measured NRMSE data from current forecasting systems shows that my predicted trend was accurate, and the change in NRMSE with time horizon closely matches a logarithmic function for each forecasting method. This means that other forecasting systems will likely follow a similar trend and the NRMSE maximum standard can also be dependent on the time horizon by a logarithmic function. For new integrated systems, NRMSE should be as low as possible but not unreasonably low as to surpass current system accuracy capabilities. To achieve this, I created a model shown by the bolded blue line in the plot above. The associated function represents the maximum NRMSE that any proposed system's short-term forecasting method should have based on its time horizon.

The storage capacity required to ensure reliability is dependent on variability. Larger variability usually means that a larger storage capacity is needed relative to system size to maintain reliability. Load variability can be approximated with the proportional difference between peak and average load, while Input power variability is determined by VRE percentage, system size, area, and resource availability.

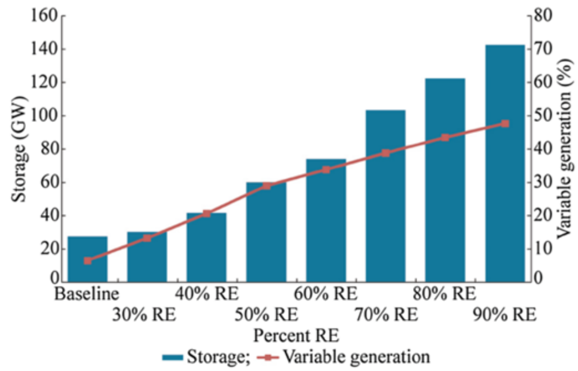

Figure 7: Storage capacity needed based on VRE percentage – Large scale prediction for entire U.S., from an NREL study

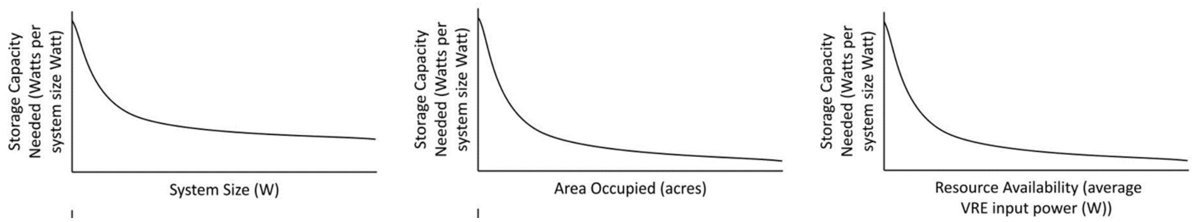

Figure 8: Projected impact of system size, area occupied, and resource availability on storage capacity needed

To create a storage capacity standard for new integrated systems, the actual impact of these three characteristics on the storage capacity needed for current systems must be determined as a ratio of system size. The data gathered in my current system analysis has allowed me to plot both system size and VRE % vs storage capacity as a ratio of system size.

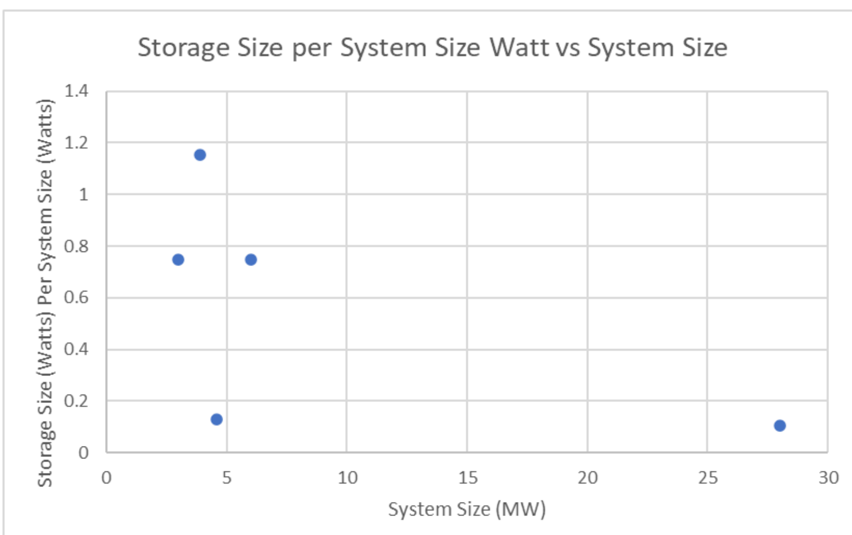

Figure 9

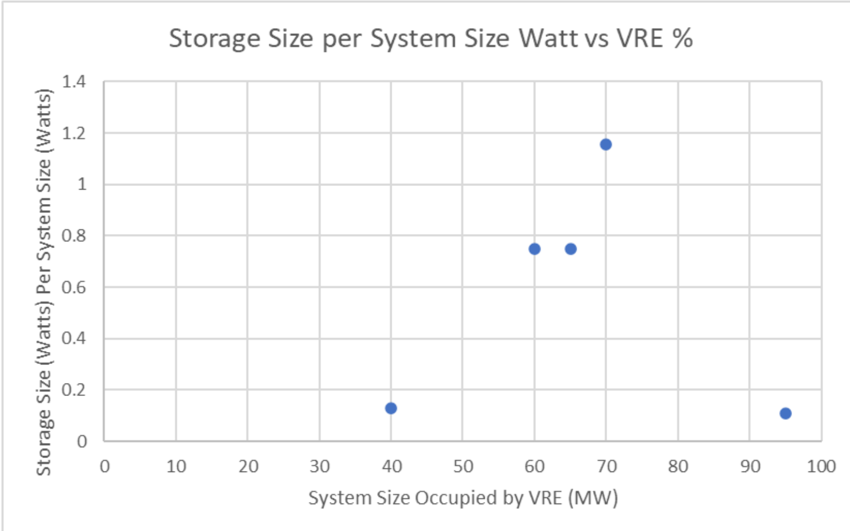

Figure 10

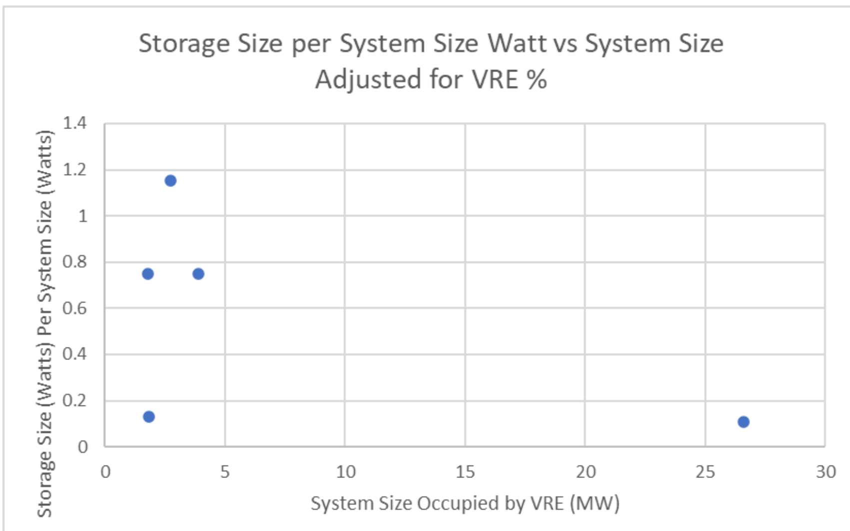

Figure 11

System size adjusted for VRE% = system size * (VRE% / 100)
This is a representation of the system size subject to variability, as uncontrolled input power variation in the system occurs at the VRE sources.

No trend can be identified in these plots. This is likely due to the systems being vastly different in other factors besides the system size or VRE %; factors that affect variability and can impact the plotted storage capacity ratio. In order to evaluate how each factor truly affects this ratio, I would have to plot data points of systems that only vary in the factor evaluated. It is near impossible to find systems that only vary in these respects, so rather than find similar systems, a comprehensive measure of variability is needed—for both load and input power—that considers every factor affecting variability. Once we have this mathematical model measuring variability, we can plot it against the storage capacity ratio and expect to see a trend. This trend should provide an idea of current system capability and allow me to create a standard for storage capacity based on known proposed system variables.

The ideal storage system(s) to implement in an integrated system depend on several factors of the integrated system, so creating a storage type reliability standard would require extensive knowledge of the specific proposed systems and a comparative evaluation of several storage methods to determine compatibility.

Admittance between each component in the system, as defined by formulas 3 and 4 in the Findings section, must adhere to a minimum value based on existing standards.

Robustness:
System Robustness Characteristics and Criteria:

Infrastructure Robustness: Robust structures and systems experience low actual stress relative to allowable stress. Allowable stress must usually exceed actual stress by a factor of safety to be deemed robust, as actual stress that nears allowable stress has the potential to create failure even if it does not exceed allowable stress. Allowable stress is defined through known material properties, while an actual stress profile is measured or simulated based on expected conditions. These conditions may consist of applied static load, vibrational load, displacement, or more. Conditions will vary from system to system and therefore must be defined for each proposed integrated system.

Seismic protection design may be implemented in the proposed system's infrastructure (DoD 3). This design must reduce seismic stress by a specified percentage based on location, system allowable stress, and actual stress from severity of seismic activity. In the event that actual stress from added seismic vibration exceeds allowable stress, seismic protection design is a good solution and must reduce the total actual stress to below allowable stress.

Other Robustness Aspects:
Voltage and current limits must be defined based on the specifications of components involved (Kroposki 2). These specifications should then be compared to expected voltage and current levels in the proposed system from operating processes and expected input power levels. Similarly, thermal limits should be defined based on component specifications (DoD 8) and compared to the expected levels from operating process and outside conditions.

Waterproof and flammability specifications for each component must be compatible with expected system conditions that vary depending on the proposed system evaluated. All materials used must be erosion and corrosion resistant for infinite life, or have a projected time to erosion / corrosion that meets or exceeds the expected life of the system.

Adequate access is necessary for periodic and emergency maintenance (DoD 3) at every critical connection and component.

Evaluation Procedures:

Infrastructure Robustness:

1. Define factor of safety for actual stress as a fraction of allowable stress
2. Define allowable stress based on components and connections involved in system
    a. Identify yield stress of each involved material / component, this is allowable stress for each
    b. Find maximum deflection to ensure continued electrical flow

        i. Conduct a tensile test to plot stress, voltage and current changes against strain
        ii. Find strain at which voltage drops / voltage sag is significant
        iii. Find the stress corresponding to this strain
    3. Allowable stress in wires is the minimum of these two identified stresses
4. Measure actual stress and strain on the system based on certain conditions
    a. Define fixed points
    b. Based on the proposed system(s) being evaluated, determine the conditions to test
    c. Conduct ANSYS FEA analysis for all conditions and see if any points on the stress profile exceed allowable stress
5. The system's infrastructure is robust if no point on the critical components' actual stress profile exceeds the allowable stress by the defined factor of safety
6. Determine any component design and sizing changes needed if this robustness condition is not met, including seismic protection that can reduce the vibrational portion of actual stress on the system
7. Repeat this analysis for the revised system with these changes, compare actual stress profiles, and determine whether this new system meets the robustness condition

ANSYS FEA Analysis Software: These ANSYS programs are needed to SImulate Actual Stress for this Evaluation as well as Expected voltage, current levels, and thermal conditions.

- Static structural analysis: Thermal expansion and contraction
    - Find expansion coefficient of materials, predict temperature range system will experience
- Fluent analysis: Wind flow (DoD 22)
- Modal analysis: Seismic vibrational load
- Thermal-electric: Expected voltage, current levels, and thermal conditions of a proposed system

Efficiency:
Characteristics and Criteria:

Minimal energy loss must be measured from input power to load provided. Efficiency is often calculated with measured energy loss, so we can apply the efficiency formula below. The system as a whole must adhere to a minimum efficiency standard and there must also be a standard for each individual, critical component.

- Efficiency = Power out / power in = Load / input power – must reach a minimum standard

Components must be compatible to ensure adequate energy transfer and stability between systems. Component specifications may indicate compatibility, but another method to evaluate compatibility is to measure energy loss across these individual components and see if it meets the standard.

The system should efficiently collect power from available resources, so for each VRE source within the system, it must reach a minimum power intake to be adequately efficient.

- Solar sources: Collector design and coating must have minimum absorptivity of 0.85 (DoD 8)

Excess power input from generation systems should be used for other purposes, whether routed to storage or to other loads. This should make near-full use of available power and prevent the need for curtailment. The lower the percentage of curtailed power as a ratio of total input power, the more efficient the system is. A curtailment percentage maximum standard should therefore be set for all proposed integrated systems.

Evaluation Procedures:

Energy loss or efficiency of the overall system can be tested on a physical system or simulated. Direct current and voltage measurements can be taken across components on a physical system, while the same can be done in a simulated system. Simulation is not ideal to determine energy loss across components or the whole system, however, because simulations assume ideal conditions and cannot incorporate real-world disturbances that cause energy loss. Simulated measurements may therefore underestimate energy loss between components.

Conclusion

This project enabled me to create a set of standards that new integrated systems must follow and are possible to evaluate. Using these standards and procedures, new integrated systems can be thoroughly evaluated to ensure the system is reliable, robust, and efficient. It is a critical step before implementation that can determine the success of an integrated system. Some of these detailed standards are measurable, while some have the potential to be measurable through analysis with the right data and existing system standards. Others among these need additional data from existing systems to create a representation of current system capabilities. Based on my results with the current standards, I know that measurable and accurate standards are achievable for each characteristic. Despite the additional challenges that high-VRE systems face, and given a thorough analysis using this report, implementation of innovative integrated systems will maintain reliability, robustness, and efficiency while reducing environmental impact for more sustainable operation.

Next Steps

Current Systems Comparison:

- Find missing data and add additional systems to Table 1
  - Will increase the number of data points and improve accuracy of current system capability analysis

Admittance:

- Find variables associated with formula
- Determine how control system structure affects calculation of admittance

Reliability Criteria:

- Create measurable service availability % minimum criteria based on current memoranda
- Define a formula to set a curtailment requirement based on monitored load, storage capacity, and any other factors relevant to the need for curtailment
- Create a functional model to determine variability based on all of the load and input power factors that impact variability
  - Use this functional model to plot minimum average input power as a ratio of average load vs variability from collected existing system data
  - Use this functional model to plot storage size as a ratio of system size vs variability from collected existing system data
- Use these plots of current system capability vs variability to create measurable standards for both the input power needed and storage size analyses

Robustness Evaluation Procedure:

- Work with identified ANSYS functions to confirm capability of performing analyses

- Determine the wind flow conditions that must be applied in fluent analysis
- Determine the scale of simulation possible for each analysis and likely components simulated

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