MANUAL

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FORCE Software Design Description

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1 Introduction

The Framework for Optimization of ResourCes and Economics is a collection of software tools,models, and datasets acquired and developed under the Integrated Energy Systems (IES) program to enable analysis of technical and economic viability of myriad IES configurations. FORCE is the consolidating interface and data repository for all the IES toolsets ranging from macrotechnoeconomic analysis to transient process modeling and experimental validation for integrated energy systems.

To accomplish this FORCE creates automated submodules and workflows for using the additional IES opensource toolsets:

- HYBRID – (`https://github.com/idaholab/hybrid`)
- HERON – (`https://github.com/idaholab/heron`)
- TEAL – (`https://github.com/idaholab/teal`)
- RAVEN – (`https://github.com/idaholab/raven`)

Each of which has its own use case purpose.

1.1 User Characteristics

The users of the FORCE software are expected to be part of any of the following categories:

- **Core developers (FORCE core team)**: These are the developers of the FORCE software or its submodules. They will be responsible for following and enforcing the appropriate software development standards. They will be responsible for designing, implementing, and maintaining the software.
- **External developers**: A Scientist or Engineer that utilizes the FORCE software and wants to extend its capabilities (new use cases, new workflow generation, etc).This user will typically have a background in modeling and simulation techniques but may only have a limited skillset when it comes to repository structure, regression testing, and version control.
- **Analysts**: These are users that will run the code and perform various analysis on the simulations they perform. These users may interact with developers of the system requesting new features and reporting bugs found and will typically make heavy use of the input file format.

1.2 Other Design Documentation

Also available within the repository is the FORCE User manual within the "docs" folder. This user manual gives a detailed explanation of the installation process, system dependencies alongside links upon which where to find them, and an explanation of the use cases within the repository.

1.3 Dependencies and Limitations

The software should be designed with the fewest possible constraints. The only primary constraint is:

1. Python 3 – `https://docs.conda.io/en/latest/miniconda.html`

However, enhanced capabilities will require the installation of the aforementioned plugins (HYBRID, HERON, RAVEN, TEAL) which have the dependencies shown below.

RAVEN

1. Visual Studio Community Edition – Link Available on the raven github
2. Raven specific python library set. – Available through the install process.

HERON, TEAL

1. Risk Analysis and Virtual ENviroment (RAVEN) – `https://raven.inl.gov/SitePages/Software%20Infrastructure.aspx`

HYBRID

1. Commercial Modelica platform Dymola – `https://www.3ds.com/products-services/catia/products/dymola/latest-release/`

2 References

- ASME NQA 1 2008 with the NQA-1a-2009 addenda, "Quality Assurance Requirements for Nuclear Facility Applications," First Edition, August 31, 2009.
- ISO/IEC/IEEE 24765:2010(E), "Systems and software engineering Vocabulary," First Edition, December 15, 2010.
- LWP 13620, "Managing Information Technology Assets"

3 Definitions and Acronyms

3.1 Definitions

- **Baseline.** A specification or product (e.g., project plan, maintenance and operations [M&O] plan, requirements, or design) that has been formally reviewed and agreed upon, that thereafter serves as the basis for use and further development, and that can be changed only by using an approved change control process. [ASME NQA-1-2008 with the NQA-1a-2009 addenda edited]
- **Validation.** Confirmation, through the provision of objective evidence (e.g., acceptance test), that the requirements for a specific intended use or application have been fulfilled. [ISO/IEC/IEEE 24765:2010(E) edited]
- **Verification.**
  - The process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase.
  - Formal proof of program correctness (e.g., requirements, design, implementation reviews, system tests). [ISO/IEC/IEEE 24765:2010(E) edited]

3.2 Acronyms

API Application Programming Interfaces

ANL Argonne National Laboratory

ARMA Auto-Regressive Moving Average

DOE Department of Energy

FMI Functional Mock-up Interface

FMU Functional Mock-up Unit

HERON Heuristic Energy Resource Optimization Network

IES Integrated Energy Systems

INL Idaho National Laboratory

NHES Nuclear-Renewable Hybrid Energy Systems

IT Information Technology

ORNL Oak Ridge National Laboratory

M&O Maintenance and Operations

NQA Nuclear Quality Assurance

POSIX Portable Operating System Interface

QA Quality Assurance

RAVEN Risk Analysis and Virtual ENviroment

SDD System Design Description

TEAL Tool for Economic Analysis

TRANSFORM Transient Simulation Framework of Reconfigurable Modules

XML eXtensible Markup Language

4 Design Stakeholders and Concerns

4.1 Design Stakeholders

- Integrated Energy Systems (IES) program
- Open-source community

4.2 Stakeholder Design Concerns

The FORCE repository is to be deployed in accordance with the funding programs reported above. No specific concerns have been raised during the design and deployment of the FORCE software.

5 Software Design

5.1 Introduction

The Framework for Optimization of ResourCes and Economics is a collection of software tools,models, and datasets acquired and developed under the Integrated Energy Systems (IES) program toenable analysis of technical and economic viability of myriad IES configurations. FORCE is the consolidating interface and data repository for all the IES toolsets ranging from macrotechnoeconomic analysis to transient process modeling and experimental validation for integrated energy systems.

FORCE leverages the work performed by prior IES analysts who are experts in HERON, HYBRID,RAVEN, TEAL, and FARM workflow development to automate workflow generation including the functionality of all of these opensource toolsets as well as distributable data and models from previous analyses.

Inputs to FORCE depend on the desired workflow. FORCE includes two primary workflows: Macro-technoeconomic analysis using HERON or transient process modeling using HYBRID. Both HERON and HYBRID leverage methods from TEAL, RAVEN, and FARM. Further,analysis in HERON informs HYBRID and vice versa. Traditionally this interaction has been manual rather than automated. FORCE delivers a unified platform for IES analysis and data transfer. This unification eliminates error prone ad-hoc coupling between the underlying toolsets and provides a consistent and singular analysis process

5.2 FORCE Repository Structure

The FORCE Repository structure will be as follows

- ***Use Cases***: Folder containing the Previous examples, Trained Data, and Original Market Data
- ***Src***: Folder containing the Plotters, Regression System, User Manual and Documentation
- ***SubModules***: Folder containing the primary submodules of FORCE.

5.3 Regression Test System

FORCE a repository that contains a series of Use Cases and base training data capable of producing potential integrated energy system configurations. To test these models the RAVEN based

regression system ROOK has been utilized. This testing system has been linked with the Continuous Integration tool to automatically test the models when new modifications are added to the repository. To do this RAVEN has been sub-moduled within FORCE.

5.3.1 Regression Tests

ROOK operates via a basic testing harness. The testing harness includes a "tests" file that contains the tolerance limits, a gold folder with a gold test file, a simulation file to run, a file with which to launch the simulation, and a directory of tests to run.

These tests are of workflows that are specific to integrated energy system workflow generation. FORCE is designed to be able to provide a techno-economic assessment of different integrated energy systems. As part of this FORCE includes the generation of workflows capable of implementing stochastic time series of wind, solar, and electric price data created via the Auto Regressive Moving Averages (ARMAs) algorithms within RAVEN into a workflow that can then be utilized. The creation of these ARMAs using data held within the FORCE repository is maintained using the ROOK system.

6 Data Design and Control

The data transfer in the FORCE framework is fully standardized:

7 Human-Machine Interface Design

There are no human system integration requirements associated with this software.

8 System Interface Design

The FORCE framework contains workflows that are usable through the standardized submodules (HERON, RAVEN, HYBRID) held within the FORCE repository

9 Security Structure

The software is accessible to the open-source community (Apache License, Version 2.0). No restrictions for downloading or redistributing is applicable.

10 REQUIREMENTS CROSS-REFERENCE

The requirements are detailed in SPC-3171, “FORCE Requirements Specification (SRS) and Traceability Matrix”.

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