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Database schema design

Energy Flexibility Environmental Tradeoffs Tool

February 2024

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U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
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Abstract

The objective of this document is to establish the database schema design for the Energy Flexibility Environmental Tradeoffs Tool.

Overview

The Energy Flexibility-Environment Tradeoff Toolset is designed using Streamlit framework, with Python as the programming language. Data storage is facilitated through the use of SQLite. Streamlit is an open-source Python framework for machine learning and data science teams [1], and SQLite is the most used database engine [2].

Acknowledgments

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Contents

1.0 Overview

The Energy Flexibility-Environment Tradeoff Toolset is designed to enable users to evaluate the effects of various operational flexibility specifications on hydropower and environmental outcomes. This toolset comprises a set of interconnected tools within an overarching framework. As shown in Figure 1, users can choose one or more tools tailored to their specific requirements, rendering this toolset adaptable and versatile for a wide range of users and applications:

1. The Evaluation Tool consists of a collection of independent tools focused on assessing diverse metrics related to hydropower and environmental outcomes under user-defined policy scenarios. These scenarios and the resulting simulation data can be generated through external processes or based on the Policy Simulation Tool.
2. Many hydropower operators may lack accessible tools to simulate comprehensive policies for a given set of inflow/demand inputs, which are necessary for evaluating trade-offs. The Policy Simulation Tool addresses this gap by providing a means to simulate reservoir operations based on predefined policy parameters.
3. The universe of potential policy levers and their associated environmental and grid outcomes is vast. Typically, only a limited number of policy scenarios are explored during hydropower environmental reviews due to the complexity of setting up scenarios and the time required for execution. The Decision Space Exploration Tool (DSET) overcomes this challenge by employing proxy relationships based on outputs from detailed modeling and other methodologies. It swiftly explores thousands to millions of operational policy variations, identifying scenarios that strike a balance between environmental and grid considerations. Proxy relationships are simplified functions that relate reservoir outputs to key output metrics (e.g., the correlation between flow rate and downstream habitat availability). The development of a Proxy Relationship Builder Tool and a Proxy Relationship Guidance Document is underway to generate these proxy relationships used as inputs for the DSET.

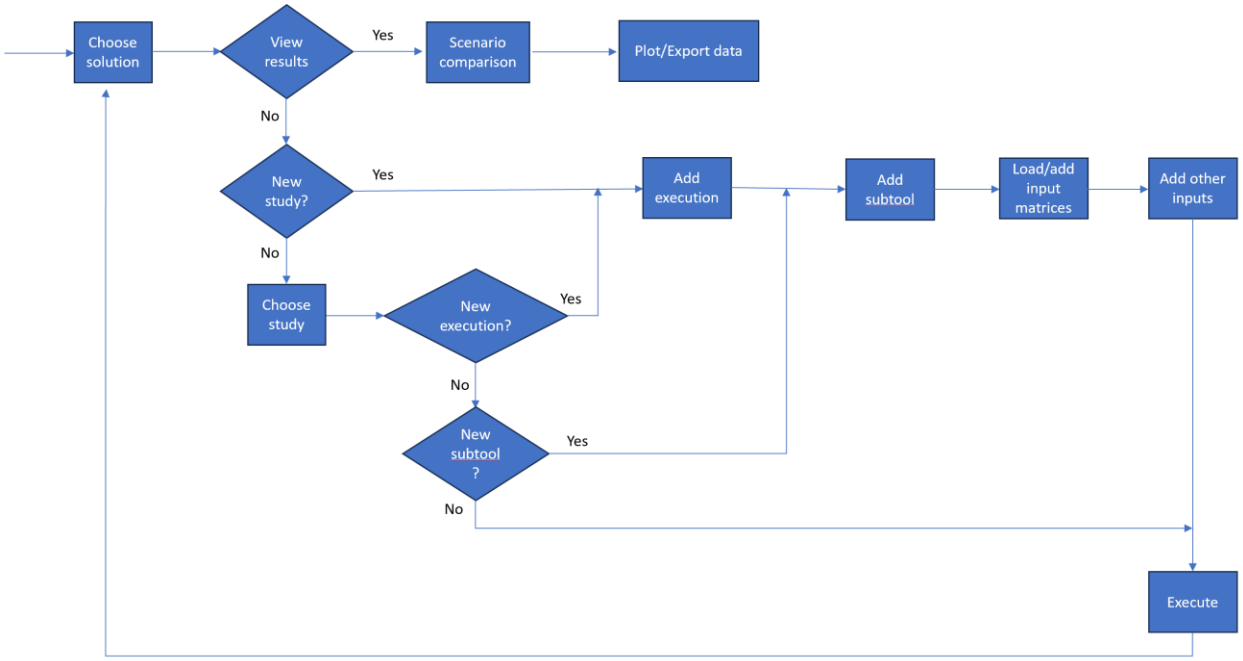


Figure 1: Overview of EFETT

2.0 Tables

2.1 Category table

The category table delineates the category to which each sub-tool belongs. There are four distinct categories: data input, reservoir simulation, environmental evaluation, and scenario comparison.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
Name	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.2 Status table

The status table specifies the status type for each study and execution. There are four distinct status types: initialized, in progress, completed, and canceled.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
Name	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.3 Time series type table

The time series type table specifies the type of time series. There are six distinct time series types: reservoir release, revenue, power production, reference, test, and forcing.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
Name	Text	No	

Description	Text	Yes	
Comments	Text	Yes	

2.4 Time series table

The time series table is used to store and organize the information of the chronological data points over a specific period of time.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
TypeID	Integer	No	Foreign key to the TimeSeriesType table
Name	Text	No	
ParamterName	Text	No	
ParamterUnit	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.5 TSData table

The TSData table is used to store the actual chronological data points of the corresponding time series.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
TSID	Integer	No	Foreign key to the TimeSeries table
Timestamp	Text	No	
Value	Float	No	

2.6 Solution table

The toolset offers preconfigured solutions for user convenience. Currently, there are three types of provided solutions: assessing and comparing habitat and revenue tradeoffs, summarizing and comparing flows, and designing flows to maximize habitat and revenue.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
Name	Text	No	
CreatedOn	Text	No	
CreatedBy	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.7 Study table

The study table is used to store information related to individual studies or research projects. This table serves as a central repository for organizing and managing information about various studies within this database.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
SolutionID	Integer	No	Foreign key to the Solution table
StatusID	Integer	No	Foreign key to the Status table
Name	Text	No	
CreatedOn	Text	No	
CreatedBy	Text	No	
StartTime	Text	No	
EndTime	Text	No	
Description	Text	Yes	

Comments	Text	Yes	

2.8 Sub tool table

The toolkit comprises multiple sub-tools created by project participants. Presently, there are six available sub-tools: decision space exploration tool, detailed policy simulation tool, habitat suitability tool, flow regime tool, scenario comparison tool, and manual input tool.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
CategoryID	Integer	No	Foreign key to the Category table
Name	Text	No	
ShortName	Text	No	
OrganizationName	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.9 Execution table

The execution table is used to store information related to each execution of the sub-tool with the same or various inputs. This table helps in tracking and managing the execution of various operations recorded in the database, providing a record of when specific inputs and their outcomes.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
StudyID	Integer	No	Foreign key to the Study table
StatusID	Integer	No	Foreign key to the Status table
Name	Text	No	
CreatedOn	Text	No	
CreatedBy	Text	No	

StartTime	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.10 Scenario table

The scenario table is used to store information related to different scenarios or situations that represent different sets of conditions or inputs that can be used to test or analyze the behavior of the corresponding sub-tool.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
ExecutionID	Integer	No	Foreign key to the Execution table
StatusID	Integer	No	Foreign key to the Status table
Name	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.11 ScenarioSubtool table

This is the conjunction table linking the scenario table and sub-tool table.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
ScenarioID	Integer	No	Foreign key to the Scenario table
SubtoolID	Integer	No	Foreign key to the Sub tool table

StatusID	Integer	No	Foreign key to the Status table
StartTime	Text	No	
EndTime	Text	Yes	

2.12 HECRASModel table

The HECRASModel table is used to store information from the HEC-RAS model file as one of the inputs for the Habitat Suitability tool.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
ScenarioSubtoolID	Integer	No	Foreign key to the ScenarioSubtool table
Name	Text	No	
FilePath	Text	No	
Version	Text	No	
Description	Text	Yes	
Comments	Text	Yes	

2.13 InputMatrix table

The InputMatrix table is utilized for storing time series data information, serving as a part of the inputs for the corresponding sub-tool.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
ScenarioSubtoolID	Integer	No	Foreign key to the ScenarioSubtool table
TimeseriesID	Integer	No	Foreign key to the Time series table

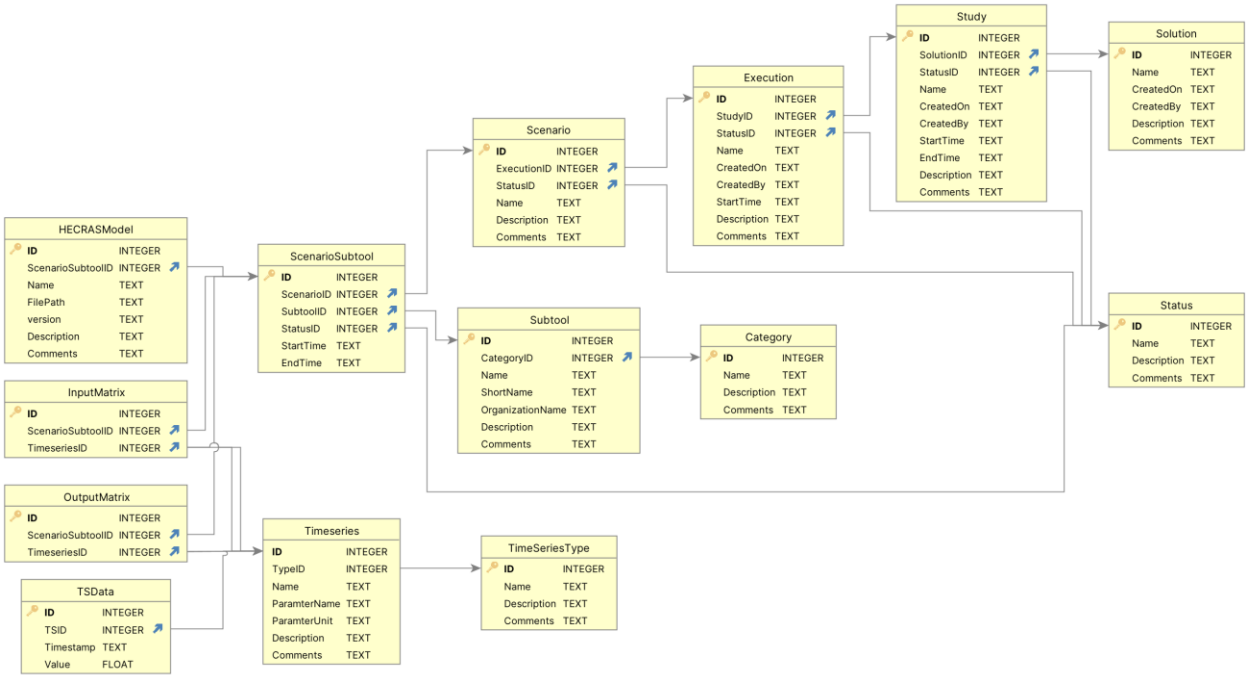
2.14 OutputMatrix table

The OutputMatrix table is utilized for storing time series data information, serving as a part of the outputs for the corresponding sub-tool.

Attribute name	Type	Nullable?	Description
ID	Integer	No	Auto increment field
ScenarioSubtoolID	Integer	No	Foreign key to the ScenarioSubtool table
TimeseriesID	Integer	No	Foreign key to the Time series table

3.0 SQLite diagram

Here is the diagram of the database:



Note:

The integer type of SQLite ranges from -9223372036854775808 to +9223372036854775807.

The date time type of SQLite is presented by the text type with the formatting “MM/dd/yyyy hh:mm:ss”.

4.0 Script to create the SQLite tables

Here is the content of the script to create the tables:

```
PRAGMA foreign_keys = ON;

CREATE TABLE Category ( ID INTEGER NOT NULL UNIQUE, Name TEXT, Description
TEXT,  Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT) );

CREATE TABLE Status ( ID INTEGER NOT NULL UNIQUE, Name TEXT, Description TEXT,
Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT) );

CREATE TABLE TimeSeriesType ( ID INTEGER NOT NULL UNIQUE, Name TEXT,
Description TEXT,  Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT) );

CREATE TABLE TimeSeries ( ID INTEGER NOT NULL UNIQUE, TypeID INTEGER, Name
TEXT, ParamterName TEXT, ParamterUnit TEXT, Description TEXT, Comments TEXT,
PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(TypeID) REFERENCES
TimeSeriesType(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE TSData ( ID INTEGER NOT NULL UNIQUE, TSID INTEGER, Timestamp
TEXT, Value float, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(TSID)
REFERENCES TimeSeries(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE Solution ( ID INTEGER NOT NULL UNIQUE,  Name TEXT, CreatedOn TEXT,
CreatedBy TEXT, Description TEXT, Comments TEXT, PRIMARY KEY(ID
AUTOINCREMENT));

CREATE TABLE Study ( ID INTEGER NOT NULL UNIQUE, SolutionID INTEGER, StatusID
INTEGER, Name TEXT, CreatedOn TEXT, CreatedBy TEXT, StartTime TEXT, EndTime TEXT,
Description TEXT, Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN
KEY(StatusID) REFERENCES Status(ID) ON DELETE CASCADE ON UPDATE NO ACTION,
FOREIGN KEY(SolutionID) REFERENCES Solution(ID) ON DELETE CASCADE ON UPDATE
NO ACTION);

CREATE TABLE Subtool ( ID INTEGER NOT NULL UNIQUE, CategoryID INTEGER, Name
TEXT, ShortName TEXT, OrganizationName TEXT, Description TEXT, Comments TEXT,
PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(CategoryID) REFERENCES
Category(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE Execution ( ID INTEGER NOT NULL UNIQUE, StudyID INTEGER, StatusID
INTEGER, Name TEXT, CreatedOn TEXT, CreatedBy TEXT, StartTime TEXT, Description
TEXT, Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(StatusID)
REFERENCES Status(ID) ON DELETE CASCADE ON UPDATE NO ACTION, FOREIGN
KEY(StudyID) REFERENCES Study(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE Scenario ( ID INTEGER NOT NULL UNIQUE, ExecutionID INTEGER,
StatusID INTEGER, Name TEXT, Description TEXT, Comments TEXT, PRIMARY KEY(ID
AUTOINCREMENT), FOREIGN KEY(StatusID) REFERENCES Status(ID) ON DELETE
CASCADE ON UPDATE NO ACTION, FOREIGN KEY(ExecutionID) REFERENCES
Execution(ID) ON DELETE CASCADE ON UPDATE NO ACTION);
```

CREATE TABLE ScenarioSubtool (ID INTEGER NOT NULL UNIQUE, ScenarioID INTEGER, SubtoolID INTEGER, StatusID INTEGER, StartTime TEXT, EndTime TEXT, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(StatusID) REFERENCES Status(ID) ON DELETE CASCADE ON UPDATE NO ACTION, FOREIGN KEY(ScenarioID) REFERENCES Scenario(ID) ON DELETE CASCADE ON UPDATE NO ACTION, FOREIGN KEY(SubtoolID) REFERENCES Subtool(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE HECRASModel (ID INTEGER NOT NULL UNIQUE, ScenarioSubtoolID INTEGER, Name TEXT, FilePath TEXT, version TEXT, Description TEXT, Comments TEXT, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(ScenarioSubtoolID) REFERENCES ScenarioSubtool(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE InputMatrix (ID INTEGER NOT NULL UNIQUE, ScenarioSubtoolID INTEGER, TimeseriesID INTEGER, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(ScenarioSubtoolID) REFERENCES ScenarioSubtool(ID) ON DELETE CASCADE ON UPDATE NO ACTION, FOREIGN KEY(TimeseriesID) REFERENCES Timeseries(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

CREATE TABLE OutputMatrix (ID INTEGER NOT NULL UNIQUE, ScenarioSubtoolID INTEGER, TimeseriesID INTEGER, PRIMARY KEY(ID AUTOINCREMENT), FOREIGN KEY(ScenarioSubtoolID) REFERENCES ScenarioSubtool(ID) ON DELETE CASCADE ON UPDATE NO ACTION, FOREIGN KEY(TimeseriesID) REFERENCES Timeseries(ID) ON DELETE CASCADE ON UPDATE NO ACTION);

5.0 References

1. A faster way to build and share data apps. https://streamlit.io/. Retrieved on 02/27/2024.

2. What Is SQLite? https://www.sqlite.org/. Retrieved on 02/27/2024.

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