Multi-Criteria Evaluation for Transportation Funding and Financing Alternatives: Supplemental Material

Developed by The University of Texas at Austin

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https://github.com/ut-ctr-nmc/fund

CONTENTS

1. INTRODUCTION

FUNding Decision (FUND) is a database application intended to provide transportation planners, policy makers and the public with a tool to assess the appropriateness of various funding and financing mechanisms according to specific project characteristics. Additionally, FUND allows users to forecast revenues of a wide selection of and expenses for the Texas Department of Transportation (TxDOT) (and with adjustment other DOTs) for an analysis period of 30 years. While the initial version of FUND was designed for Texas, the functionality can be easily transferrable to other contexts and government levels. However, efforts should be spent on tailoring the assumptions and inputs to for a specific state's finances and processes as described in later sections of this document.

Through an interactive interface described in Section 2, the user can select to run the Appropriateness or the Projections Module. Within the **Appropriateness Module**, the user can control all variables related to project characteristics. Additionally, background calculation assumptions can also be modified to meet specific user needs. The output of the appropriateness module is the ranking of funding and financing mechanisms based on project characteristics. Within the **Projections Module**, the user can select inputs regarding statewide transportation needs, population growth rates, fuel efficiency, inflation rates, taxes, fees and other elements. The output is a set of tables and graphs showing a forecast of revenues for each year of the analysis period corresponding to various funding and financing mechanisms.

This tool is not intended to be used in and of itself to make final funding and financing decisions. However, it is designed to merely provide practitioners with insights of the available innovating and financing alternatives within a quantitative framework. At this stage, FUND should only complement the current processes while it could act as a standalone decision framework upon further validation from experts as well as local and state transportation agencies.

It is also essential to reiterate that FUND will need to be updated regularly to incorporate new criteria and funding/financing alternatives as they emerge. Additionally, updates should be made by every user to tailor the tool to their specific financing landscape.

This document covers the models embedded within FUND, the required inputs, step by step overview of the calculations, and the possible outputs. This report also describes how to open FUND, as well as how to accomplish tasks via the user interface. Additionally, several exhibits are provided (orange boxes) across the report that explain how the calculations are implemented in the Excel background sheets and how can the users modify the inputs as they see fit.

This document represents the user guide for FUND and the online supplement to the following research article. Please cite this article if FUND is useful for your purposes.

> Haddad, A. J., G. Blazanin, K. A. Perrine, and C. R. Bhat. (2021). *Multi-Criteria Evaluation for Transportation Funding and Financing Alternatives.* Manuscript submitted for publication to Transportation Research Record.

The authors thank the Texas Department of Transportation (TxDOT) for financially supporting this research, under project 0-7065, “Develop Innovative Financing Mechanisms in a Fast-Changing Texas Transportation Landscape”. The authors also gratefully thank Shuqing Kang who conducted early research efforts. Items referenced in this document are available at https://github.com/ut-ctr-nmc/fund.

2. GETTING STARTED

FUND is comprised as a Microsoft Access 2016-based database application that assists in identifying funding and financing sources that are potentially available on a statewide basis, and appropriate for a proposed project. The tool provides these functions:

- **Projections**, which assist in estimating funding availability based upon economic factors; and
- **Appropriateness** for matching funding and financing types to project characteristics.

In short, the Access database and application contain modules implemented as embedded Excel workbooks that allow for the computation of results presented as projections and appropriateness rankings. Input parameters for these are collected via database-driven questionnaires presented in the Access user interface.

This section describes how to install and open FUND, as well as how to accomplish tasks via the user interface.

Files Download

The FUND application is available on the web at **https://github.com/ut-ctr-nmc/fund**

Within the GitHub repository is the packaged Access database file, this documentation, a sample survey document (`expert_panel_survey_sample.doc`), and Excel files for the Appropriateness and Projections calculations. While Excel files are embedded within the Access database file, they are provided as separate files here for convenience.

System requirements

To open and run FUND, the following system requirements should be met:

- Windows system that can run Access 2016 or newer
- Microsoft Access 2016 or newer
- Microsoft Excel 2016 or newer

Opening FUND

To open FUND, navigate to the relevant directory in Windows File Explorer, and double-click on the `fund_v3a_2021531.accdb` file.

Alternatively, start Microsoft Access and then use its "Open Database" function to open `fund_v3a_2021531.accdb`.

Initial Run

If you are opening the FUND database version for the first time, it is necessary to first enable the scripts that support the operation of the FUND user interface and computations. After clicking the "Enable Content" button, as shown in Figure 2-1 below, you will be able to use the application.

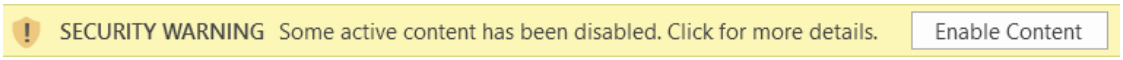


Figure 2-1 Warning Message

3. TITLE SCREEN

This section describes the interface of the first page and how to navigate the options it provides. When the database is open, the FUND title screen (shown below) will appear that displays the version number and a high-level flowchart of application functionality.

From here, the title screen allows choosing from two options, as shown in the figure below.

- The “Projections” module defines the economic and non-economic projections that may impact the course of a project. The user can add many inputs here to create a unique economic scenario to help guide for various funding sources.
- The “Appropriateness” module asks overarching questions about a project, such as project base cost and expected duration. It also asks qualitative questions about the project that can then be used to determine which funding and financing mechanisms would be appropriate for the project.

Both Projections and Appropriateness require users to select a profile or scenario from a drop-down menu before proceeding. These scenarios are associated with a set of inputs that were programmed by the application developers to facilitate running the models. The Appropriateness Module also doubles as a means to search among viable funding and financing mechanisms for the purposes of exploration and education.

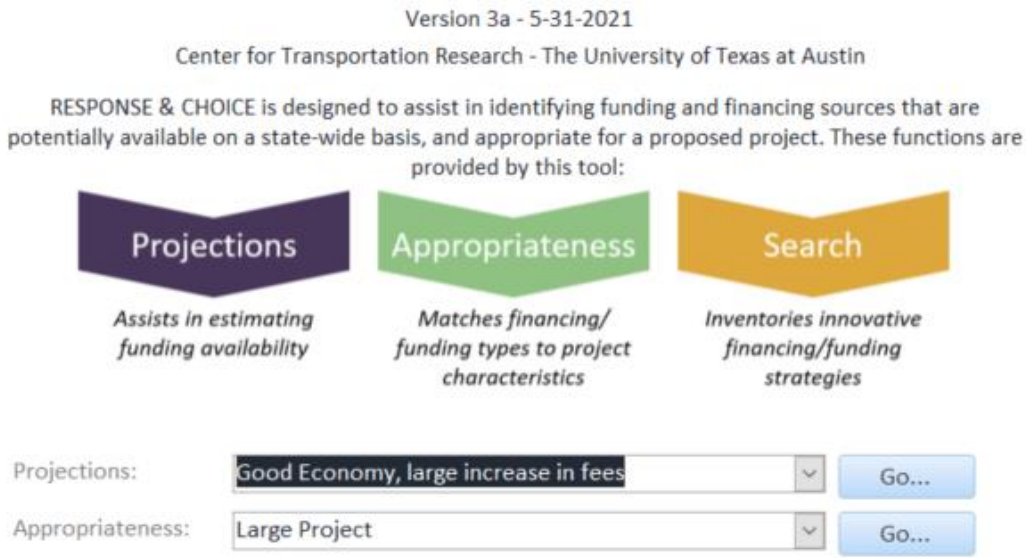


Figure 3-1 FUND Title Page User Interface

4. APPROPRIATENESS MODULE

4.1. Navigating the User interface

If the user is interested in running the Appropriateness functionality, the following steps should be followed to go from the main page to the inputs page and finally the results page. In brief, we describe the steps and techniques to complete the process, followed by a more detailed explanation.

4.1.1. Main Page

The first step involves navigating to the start page of the user selects "Appropriateness". Then, the user selects a specific project type or profile that may best fit the project at hand from the dropdown menu, as shown under Step 1 in **Figure 4-1**. These profiles include the following options:

- Large project
- Mid to small-sized project
- Mid-sized project
- Small project
- Default

Refer to **Section 4.2** for a detailed explanation of how these project profiles were generated and a rundown of their associated input variables. If none of the profiles fit the project characteristics, select the "Default" profile at this step and the software will allow updating a pre-loaded profile or creating a new profile on the next page.

To transfer from the main page to the inputs page click the "Go" button, as shown under Step 2 in **Figure 4-1**.

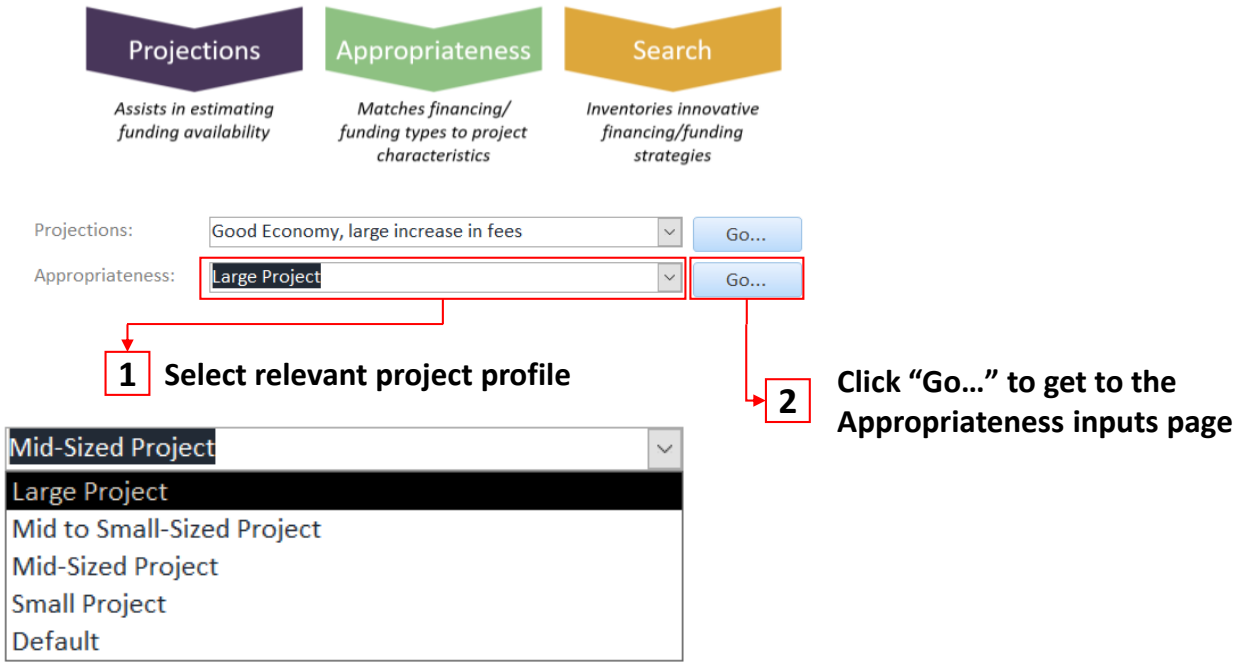


Figure 4-1 Appropriateness Project Profile Selection Menu

4.1.2. Inputs Page

After the Go button is clicked on the main page, a question module appears for the Appropriateness Inputs, as shown in **Figure 4-2**. The first step on this page is in selecting characteristics for a model project for this analysis. On the top of the screen (refer to Step 1 within **Figure 4-2**) is the mechanism for selecting, creating, and saving profiles. Each profile may have a memo associated with it to help distinguish the purpose of the profile. Additionally, each profile corresponds to a set of answers that get loaded into the Inputs Page. For example, **Figure 4-2** shows the pre-loaded answers for the "Large Project" profile.

Step 2 of **Figure 4-2** shows all the questions and the list of options from which one may be selected to refer to project-specific characteristics on the Appropriateness Inputs page. All the answers offered in this module are categorical. Within this step, the user selects desired project characteristics and adjusts any irrelevant ones that were set by default.

In working with profiles, the following functions are possible:

- **Select an existing profile**: choose the profile name from the list. If you have any unsaved changes in the form, the unsaved changes will be lost. Save first under an existing or new profile before selecting a different profile.
- **Create and save a new profile**: record answers to questions and update the profile name in the profile list field and description in the memo field. Then, save the changes by clicking on the "Save" button, as shown in Step 3 of **Figure** 4-2. If the user neglects to rename the profile being saved, the system will provide a warning that the changes will overwrite what is already in the default.
- **Delete a profile**: select a profile (unless the profile to be deleted is already selected), and click on the "Delete" button. Default profiles cannot be deleted. After the deletion, another profile name will need to be selected or entered in order for the answer to questions to be saved.

Saving new profiles is an essential function within FUND as it populates the database with commonly encountered project scenarios in the user's context. These profiles and the answers associated with them are saved in the database, allowing them to persist between runs. This also allows multiple users to access the profiles in cases where the Access database file is shared through file-share systems or e-mail.

A final note: providing the same exact inputs each time will produce the exact same results. Changing the inputs to be accurate to the project at hand is vital to correctly predict appropriate funding or financing mechanisms.

Click the "OK" button when completed, as shown in Step 4 of **Figure 4-2**.

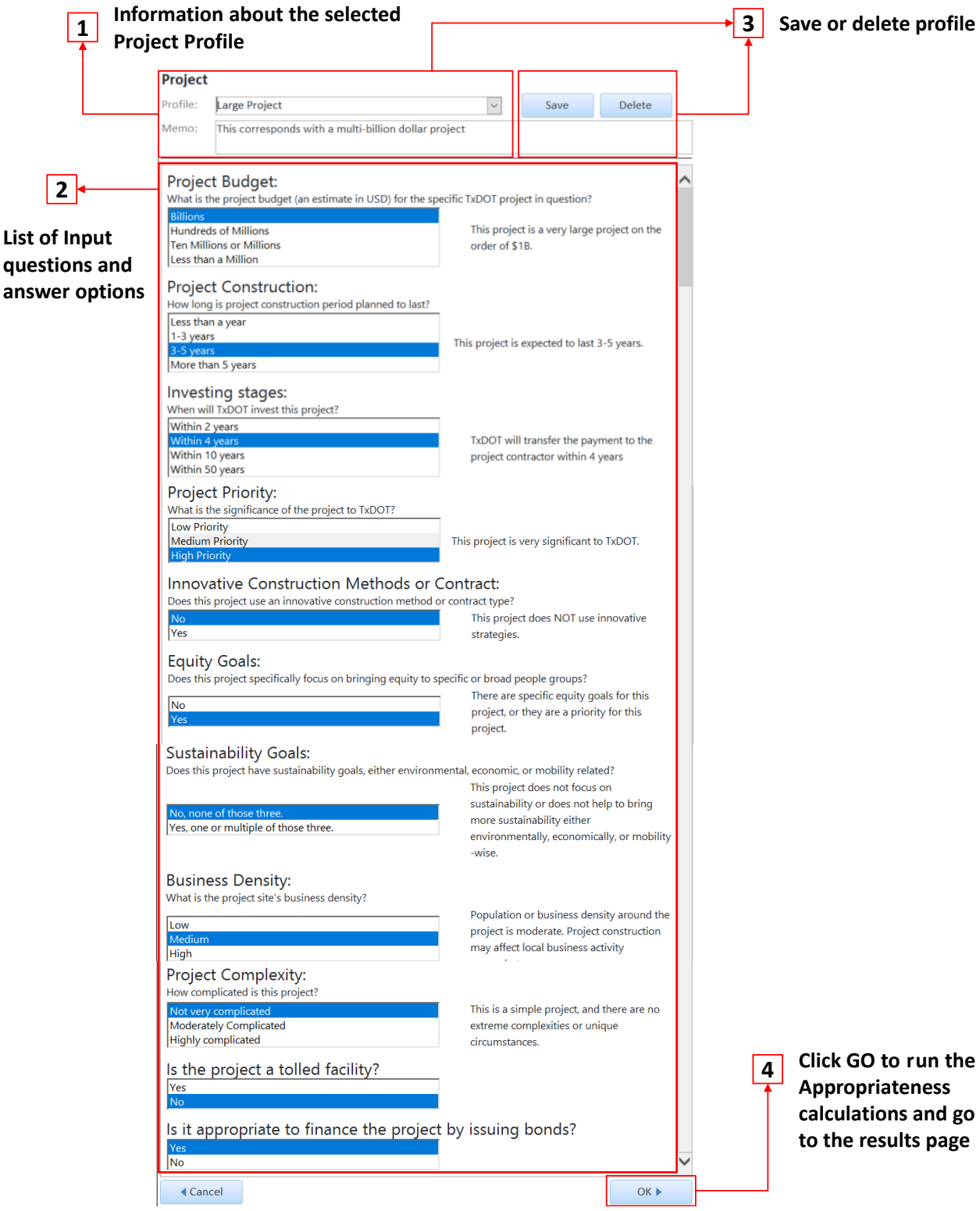


Figure 4-2 Appropriateness Inputs Page User Interface

4.1.3. Results Page

The results page generates a report for Appropriateness that summarizes the results of calculations made on the model given the inputs specified by answers associated with the profiles that are selected on the title screen. An example of a report output is shown in **Figure 4-3** below.

In this screen, scores resulting from calculations made for each financing and funding mechanism are shown in a sorted list box, as shown in Step 1 of **Figure 4-3**. The most appropriate funding/financing mechanism appears at the top of the database with a rank of one, while scrolling down will reveal the least appropriate mechanisms.

When one financing/funding mechanism in the table is selected (by clicking on it), information showing details about the mechanism's description, advantages and disadvantages, and additional references, as shown in Step 2 of **Figure 4-3**. A click on a reference link will open up a new web browser.

All financing and funding mechanisms that are available in the list must have scores greater than 0. If the configuration of answers yields no results that have positive scores, then the list is empty and the lower portion of the screen displays a note saying that no results are found.

The "Prev" button will close the results window and return to the list of questions if needed, as shown in Step 2 of **Figure 4-3**.

A "Details" button is also provided to supply the user with additional information about the presented results. The "Details" button is displayed on the top right, as shown in Step 4 of **Figure 4-3**, and will take the user to a more detailed results page. This page contains criteria weights given (both in tabular and graphical forms), as well as the actual scores and ranks for each of the mechanisms, as shown in **Figure 4-4**.

Overall, users should be able to use both results pages to better their understanding of mechanisms that may work well for their project as well as understand what criteria in the mechanisms is most important to look for. Even if the mechanism is not coded within this database, the criteria weights shown are sufficient to transfer to new mechanisms.

Refer to **Section 4.3.2.1** for criteria considered in ranking the funding/financing mechanisms as well as the calculations used to run the Appropriateness Module.

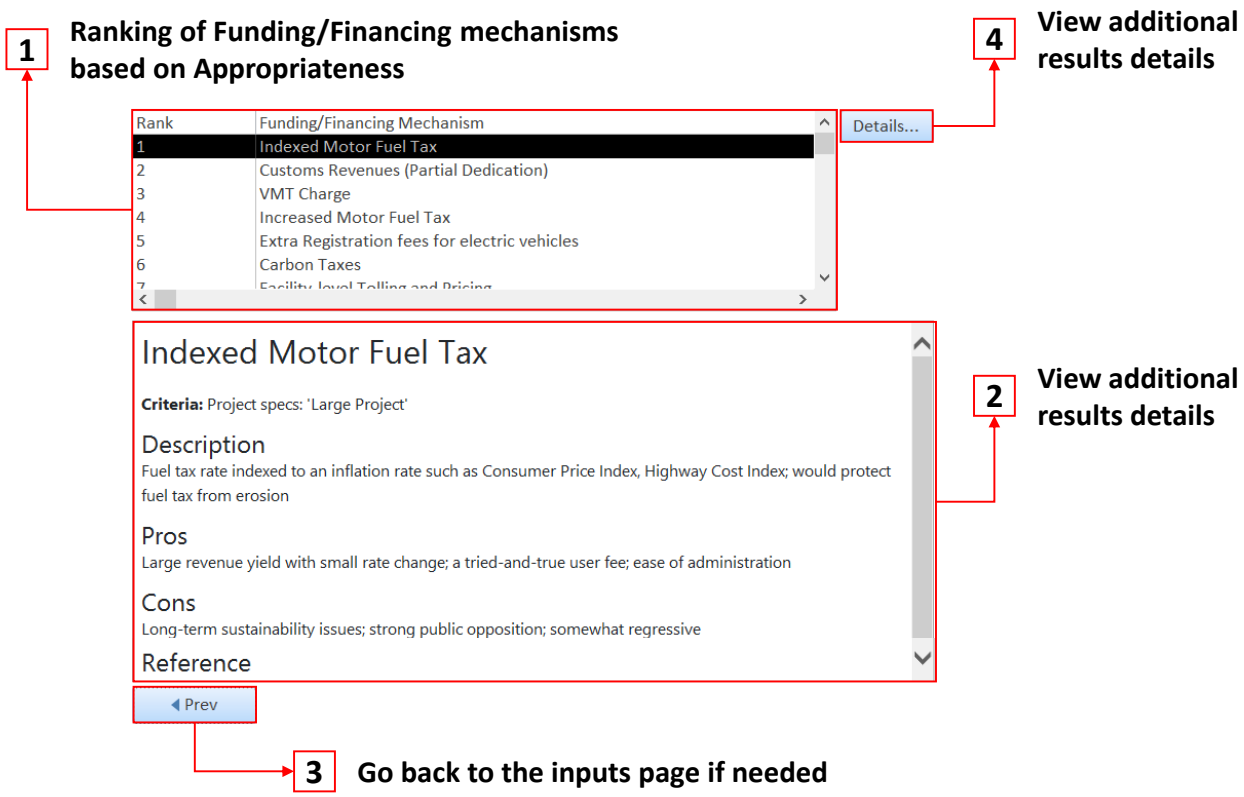
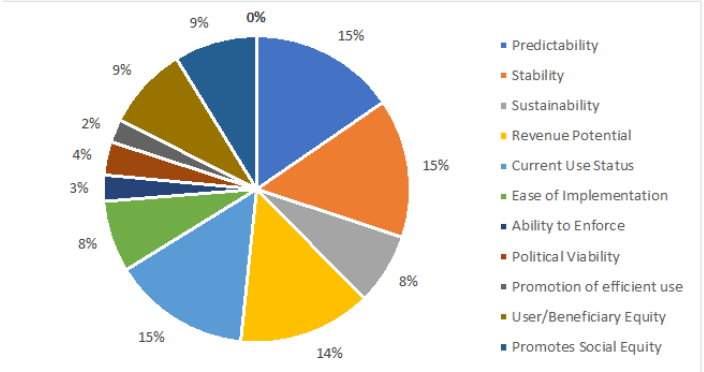


Figure 4-3 Appropriateness Results Page User Interface

Criteria	Weight
Predictability	15%
Stability	15%
Sustainability	8%
Revenue Potential	14%
Current Use Status	15%
Ease of Implementation	8%
Ability to Enforce	3%
Political Viability	4%
Promotion of efficient use	2%
User/Beneficiary Equity	9%
Promotes Social Equity	9%
Placeholder	0%
Placeholder	0%
Placeholder	0%



Mechanism	Score	Rank
Customs Revenues (Partial Dedication)	5.98%	2
Indexed Motor Fuel Tax	6.47%	1
Increased Motor Fuel Tax	5.49%	4
VMT Charge	5.98%	3
Tax Increment Financing (TIF-TRZ)	3.36%	20
Impact Fee	3.36%	21
Congestion Charges	3.38%	19
Cordon Pricing	3.29%	22
Container Fees/Tax	4.36%	9
Carbon Taxes	5.11%	6
Freight Bill	3.80%	13
Freight Charge: Ton or Ton-Mile	3.72%	14
Facility-level Tolling and Pricing	4.83%	7
Heavy Vehicle Use Tax	4.21%	10
Imported Oil Tax	2.91%	23
Sales Tax: Auto-related Parts & Services	4.07%	11
Variable Parking Fee	3.48%	18
Transportation-Utility Fee	4.72%	8
EV Fee	5.30%	5
Toll Revenue Bonds	1.04%	24
TIFIA	4.06%	12
PAB	3.70%	15
General Obligation Bond	3.70%	15
Revenue Bond	3.70%	15

Figure 4-4 Detailed Appropriateness Results Page

4.2. Pre-loaded Project Profiles

The four project profiles that were pre-loaded into FUND's Appropriateness module are summarized in **Table 4-1**. The table shows the default inputs for each profile in the exact they appear in the Inputs page shown in **Figure 4-2**. Additionally, a description is provided in **Table 4-1** to explain each variable.

It is important to re-iterate that FUND users are not restricted to these four profiles and can edit the inputs as they see fit.

Table 4-1 Characteristics of Each Project Scenario

Characteristic		**1**	**2**	**3**	**4**
Budget	Billions	x			
	Hundreds of Millions		x		
	Millions			x	
	Less than a Million				x
Construction Period: *Reflects how long the project construction is planned to last*	Less than a year				x
	1 to 3 years		x	x	
	3 to 5 years	x			
	More than 5 years				
Investment Timing: *Exact investment timing provides clarity of scope and likelihood of cost changes*	Within 2 years			x	x
	Within 4 years	x	x		
	Within 10				
	Within 50 years				
Project Priority: *Reflects the significance of the project*	Low			x	x
	Medium				
	High	x	x		
Innovative Construction or Delivery Methods:	Yes		x		
	No	x		x	x
Equity Objectives: *If the agency or the particular project have equity goals that should be met.*	Yes	x	x	x	x
	No				
Sustainability Objectives: *If the agency or the particular project have sustainability goals that should be met.*	Yes	x	x	x	
	No				x
Business Density: *Reflects the economic landscape of the project location*	Low				x
	Medium	x	x		
	High			x	
Complexity: *Reflects the level of experience required personnel to be hired*	Not very complicated	x			x
	Moderately complicated			x	
	Highly complicated		x		
Tolled Facility	Yes				
	No	x	x	x	x
Appropriateness of Issuing Bonds	Yes				
	No	x	x	x	x

4.3. Calculations

One of the main objectives of this study is to implement a decision-aiding framework that ranks funding/financing mechanisms according to their appropriateness to fund user-specified projects with specific characteristics. This objective is achieved by capturing the characteristics of the transportation infrastructure project at hand through a set of questions and implementing the Analytic Hierarchy Process (AHP) as a computational process to determine the appropriateness score of each mechanism. This section describes the calculations that take place in FUND's background to collect project characteristics and relate them to the appropriateness of each funding/financing mechanism.

Figure 4-5 provides an overview of the major components of the framework developed in this study to rank financing mechanisms using AHP; each component is discussed in detail in the next sections. The solid-colored boxes in Figure 4-5 represent the main outcome of each component (*1*).

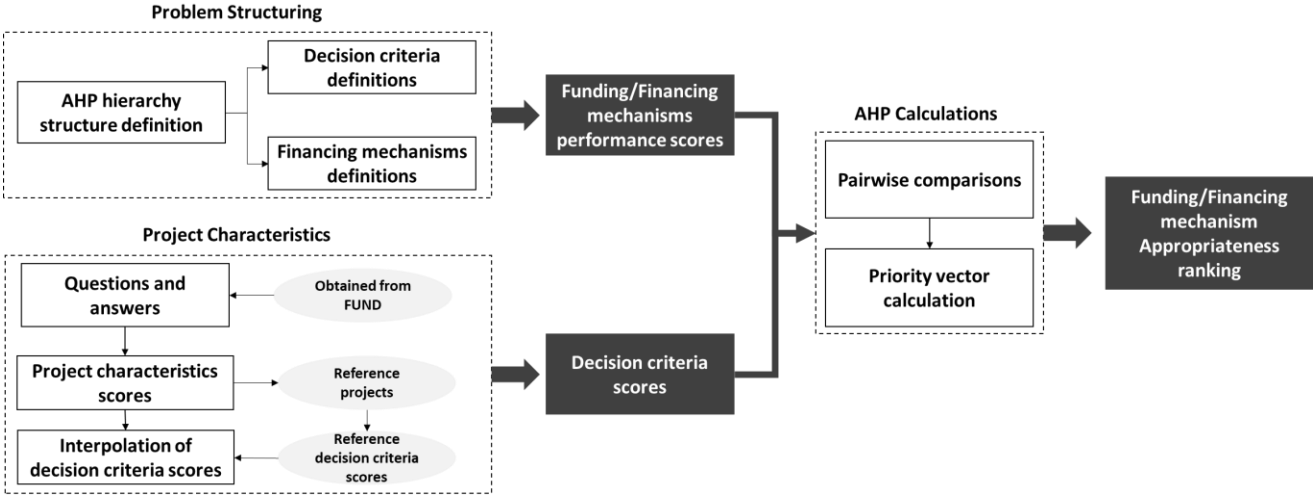


Figure 4-5 AHP Framework for Funding/Financing Mechanisms Appropriateness

4.3.1. MCDA and AHP Concept

Multi-criteria decision analysis (MCDA) methods have been developed to support decisions that involve conflicting multiple criteria. MCDA methods provide a systematic evaluation process that is transparent and repeatable, capable of eliciting expert opinions, better understood by the public and policymakers (*2*, *3*). Briniewicz and Ogrodnik (2020) recognized over 58 articles that employ MCDA methods to facilitate decision-making in the field of transportation over the last 20 years (*4*). Based on their exhaustive review, they concluded that the AHP is the most popular MCDA method for solving complex and unstructured problems through a systematic logical analysis. AHP has been used in different fields and disciplines. Its ability to handle both qualitative and quantitative data makes AHP an ideal methodology for this particular prioritization problem (*5*).

AHP involves pairwise comparisons between criteria and options to facilitate the selection of the best alternative (*6*, *7*). It provides a mathematical framework for decomposing and structuring complex problems and involves 6 main steps: (a) structuring, (b) prioritizing through pairwise comparisons, (c) obtaining a priority vector for decision criteria, (d) computing the matrix of option (alternative) scores, (e) checking for consistency in the preference judgments, and (f) ranking the options (*1*).

The first AHP principle involves the structuring of a hierarchy. The problem is structured as a hierarchy that decomposes the problem into individual levels. The top level is the goal of the decision, the second level represents the decision-making criteria, and the third level represents the alternatives (*7*, *8*). After establishing the problem structure, pairwise comparisons are conducted to determine the relative differences between criteria pairs. The AHP method recommends using a nine-point scale to quantify the degree of importance of one criterion over the other. The relative importance of the two elements is assigned a value of one if they are equally important, a value of three if one element is moderately more important, a value of five if one element is strongly more important, a value of seven if one element is very strongly more important, and a value of nine if one element is extremely more important. Values of two, four, six, and eight are considered for intermediate relationships (*8*). The outcome of the pairwise comparisons is a positive reciprocal matrix **A** of dimensions *m*×*m*, where *m* is the number of evaluation criteria considered. Each entry a_{jk} of matrix **A** represents the importance of the jth criterion relative to the kth criterion.

The synthesis of the criteria priorities (or weights) from pairwise comparisons is the cornerstone of the mathematics behind the AHP method. Saaty's eigenvalue approximation is performed to derive priority vector W using Equation (1) (*5*, *9*).

$$AW = \lambda_{\max} W \tag{1}$$

Where **W** is the weight vector for the considered criteria and $\lambda_{\max}$ is the principal eigenvalue of matrix **A** (principal means the largest eigenvalue of the matrix).

However, this methodology can be simplified by "the approximate method," which requires only additions and averages to achieve the same outcomes (*7*, *8*, *10*). This method comprises of normalizing the columns of matrix **A** and averaging the resulting values across each row, as presented in Equations (2) and (3), respectively.

$$\overline{a_{ij}} = \frac{a_{ij}}{\sum_j a_{ij}} \tag{2}$$

$$w_i = \frac{\sum_i \overline{a_{ij}}}{m} \tag{3}$$

where w_i is the decision weight for criteria *i*.

In a similar manner to the pairwise criteria comparisons, the candidate alternatives are compared with respect to each of the *m* criteria. This results in pairwise comparison matrices $\mathbf{B}^{(j)}$ where j=1,...,*m*. The same eigenvalue approximations conducted for matrix **A** are also used to estimate the scores of the evaluated options with respect to each criterion. These calculations result in scores matrix **S**. Each entry s_{ij} of **S** represents the score of the ith option with respect to the jth criterion. Once the weight vector **W** and score matrix **S** are computed, the global score that ranks the different alternatives is obtained using Equation (4).

$$v = S \cdot w \tag{4}$$

The ith entry v_i of v represents the global score assigned by the AHP to the ith option. As the final step, the option ranking is accomplished by ordering the global scores in decreasing order.

Prior to accepting the results, a consistency check should be performed to ensure that the pairwise comparisons were conducted logically. The eigenvector method which provides a robust estimation also provides the means of assessing the relative inconsistency of pairwise comparison matrices (*11*). The AHP has a built-in mechanism to detect and prevent inconsistencies that may arise when performing many pairwise comparisons. The technique relies on the computation of a suitable consistency index (CI). The consistency index is based on maximum Eigenvalue (λ_{max}), which is calculated by summing the product of each element in the Eigenvector by the respective criteria total of the original comparison matrix **A**. The calculation of the CI is given by Equation (5) (*8*).

$$CI = \frac{\lambda_{max} - m}{m-1} \quad (5)$$

where m is the number of evaluated criteria.

Saaty and other researchers have generated various random matrices for each *m*-size matrix and have calculated those matrices' mean CI values. This mean CI value is known as the random inconsistency index (RI). The RI value is fixed and is based on the number of evaluated criteria. Finally, a consistency ratio (CR) is the ratio of CI and RI is evaluated to quantify inconsistency. A matrix is considered consistent only if CR ≤ 0.1.

4.3.2. Design of AHP for Evaluating Appropriateness

The steps described in this section strictly adhere to the framework presented in Figure 4-5.

4.3.2.1. Problem Structuring

The AHP hierarchy structure definitions (leftmost box within the "Problem Structuring" block in **Figure** 4-5) used for the AHP analysis are designed to address the main goal—selecting the most suitable funding/financing plans for user-specified projects. The overall objective is to rank funding/financing mechanisms, which is placed at the top level in the hierarchy (Level 0) as shown in
Figure 4-6. Level 1 includes the criteria for evaluating the performance of alternatives, while the alternatives themselves are placed at the bottom level (Level 2) of the hierarchy (*1*).

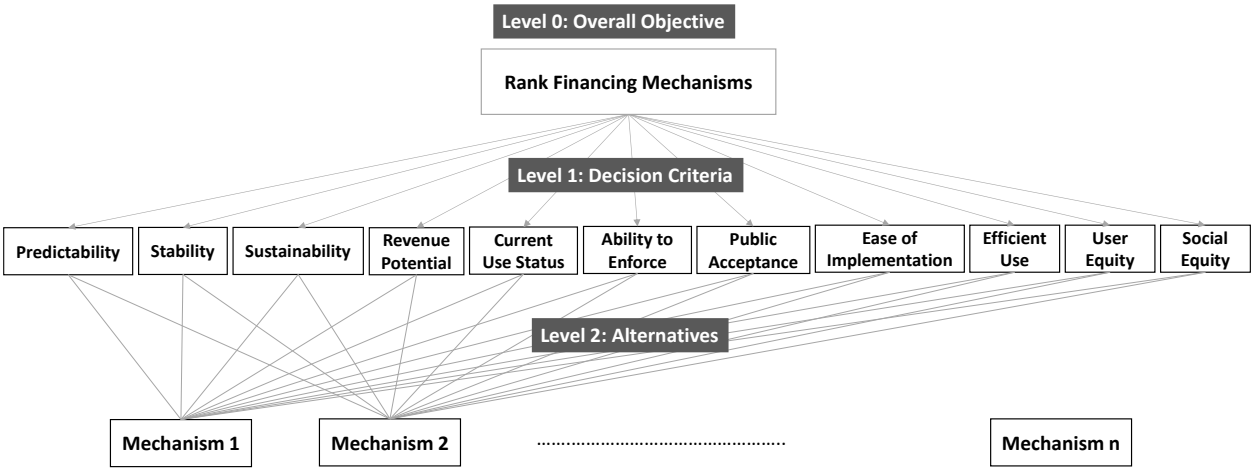


Figure 4-6 Hierarchy Structure for AHP Analysis (*1*)

To generate supportable results that meet the main goal, the appropriateness of funding or financing mechanisms for transportation infrastructure projects is evaluated based on a set of deciding criteria previously established in the literature (*12*–*18*). This process is presented in the decision criteria definitions box located on the top-right box within the "Problem Structuring" block of **Figure** 4-5 (*1*). This list includes four main categories, with sub-categories, as presented in **Table 4-2.**

Table 4-2 Funding/Financing Criteria Adopted in the Appropriateness Module (*1*)

Criteria	Description
Revenue Stream Considerations	
Predictability	Predictability reflects the presence of sufficient information to make reliable predictions and reliably forecast any possible variations in revenue generation.
Stability	The stability criterion refers to the level of uncertainty and fluctuation in revenues that can impact an agency's ability to manage resources. Stable mechanisms are not expected to deviate significantly during periods of economic downturn or changes in travel behavior.
Sustainability	Sustainability reflects the degree or extent to which a mechanism can be adjusted to keep pace with inflation and funding demand changes. This also involves the scalability to meet funding demands. This measure can also reflect the timeframe during which the mechanism remains a viable revenue source. The authors took these considerations into account while deriving the sustainability of alternative revenue mechanisms.
Revenue potential	Revenue potential is a measure of an individual mechanism's ability to yield significant revenue. For the scope of this study, mechanisms' revenue potential is considered in the context of funding for the overall surface transportation system. Consequently, mechanisms must generate significant revenue, such as that achieved by the gas tax, to receive a high score.

Implementation and Administration Considerations	
Current use status	This criterion reflects whether a mechanism is currently in use at the specific state level, being considered, or completely new.
Ease of implementation	Ease of implementation reflects the complexity and cost of implementing and administering new funding mechanisms.
Ability to enforce	The ability to enforce reflects a mechanism's enforcement complexity and cost—it is a measure of the resources an agency has to invest to minimize payer evasion.
Public acceptance (Political viability)	This criterion reflects a mechanism's ability to gain public acceptance, which in turn has a direct impact on the political viability of the mechanism. The level of public acceptance is dynamic and can change depending on technological advances or educational efforts.
Economic Efficiency and Impact Considerations	
Promotion of efficient use	This criterion reflects the extent to which a mechanism promotes and incentivizes the efficient use of the system by influencing travel choices and behaviors. Efficient system use reduces additional infrastructure investment needs. This criterion is also tied with the mechanism's ability to reduce the adverse side effects of the transportation investment, such as pollution, noise, and congestion.
Equity Considerations	
User/beneficiary equity	User equity reflects the extent to which a mechanism charges those who directly use and benefit from the transportation infrastructure investment.
Promotion of social equity	Social equity reflects the fairness of tax or fee burden among different economic groups and geographic locations. Mechanisms that result in a disproportionate burden on lower-income groups would score low on this criterion.

The financing mechanisms definitions (the bottom-right box within the "Problem Structuring" block of **Figure** 4-6) list all of the mechanisms available as alternatives in the FUND database. To evaluate the mechanisms, we used a five-point scoring system based on a thorough review of the literature on this topic (*14*, *16*, *17*, *19–22*). A low score means the option ranks poorly and a high score means it ranks well under the associated criterion. **Table 4-3** presents the assigned funding/financing mechanisms performance scores (the output of the "Problem Structuring" block of **Figure** 4-5). The scores of the alternatives over each criterion are also presented alongside a description of the alternative and its main advantages and disadvantages. It is worth noting that it is advantageous to modify these scores based on the experience of the agency using FUND (*1*).

Table 4-3 List of Funding and Financing Mechanisms

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
Customs Revenues: Partial Dedication (*23*)	Customs duties are imposed at varying rates on various imported goods passing through U.S. international gateways and currently flow into the General Fund of the U.S. Treasury. A number of interest groups, as well as the National Surface Transportation Policy and Revenue Study Commission, have suggested that, given the role transportation infrastructure plays in facilitating the import of goods, a portion of current customs duties should be allocated to support transportation investment. **Pros:** Small percentage of current revenues provides significant revenues; highly sustainable. **Cons:** Diverts or expands a mechanism that is currently used and viewed as an important U.S. General Fund revenue source	4	4	5	4	1	3	5	4	2	3	3
Indexed Fuel Tax (*24*)	Fuel tax rate indexed to an inflation rate such as Consumer Price Index, Highway Cost Index; would protect fuel tax from erosion. **Pros:** Large revenue yield with small rate change; a tried-and-true user fee; ease of administration. **Cons:** Long-term sustainability issues; strong public opposition; somewhat regressive	4	4.5	3.5	5	0	3	4	5	4	4	3
Increased Motor Fuel Tax Rate (*25*)	The fuel tax rate increased to a rate that would enhance its purchasing power. **Pros:** Large revenue yield with small rate change; a tried-and-true user fee; ease of administration. **Cons:** Long-term sustainability issues; strong public opposition; somewhat regressive	4	4.5	2.5	4	0	2	5	5	4	4	3
Vehicle Miles Traveled Fee (*26*)	Drivers can be charged for the total number of vehicle miles traveled (VMT), regardless of the road used or the time of day. The fee can be charged in a number of ways. Oregon launched its OReGO Program in 2015, which is the nation's first operable	3	4	5	5	0	1	1	2	5	5	3

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	road usage charge (RUC) system. Under this system, over 1,300 vehicles pay a per-mile fee in lieu of the state gas tax, with either a global positioning system (GPS)-enabled mileage-reporting device (MRD), or an MRD without GPS. Several other states have launched RUC pilots. **Pros:** Large revenue yield potential; highly sustainable; appropriate user fee; leads to more efficient use of the system. **Cons:** Public and political opposition is high, especially on privacy grounds; considerable costs and challenges (institutional, administrative, and cultural); not enough real-world experience with implementation; not a viable short-term option											
Tax Increment Financing (TIF-TRZ) (*27*)	Fees paid by developers to offset infrastructure costs; includes impact fee, tax increment financing, value capture. **Pros:** Closely linked to the demand for transportation improvements on the state highway system, as well as on county and municipal roads; the developers who pay these charges pass them on to the consumers who benefit from the developed sites. **Cons:** Not efficient as a primary revenue mechanism as these taxes are focused on specific location; highly dependent on economic cycles, creating a large degree of unpredictability and risk for the targeted project; as a form of real estate tax, it may divert funds from other local priorities	2	2.5	3	2	1	3	4	4	1	2	3
Impact Fee (*27*)	One-time payment for growth-related infrastructure, usually collected at the time building permits are issued. **Pros:** Existing development does not subsidize new development; transportation capacity is essential to accommodate new development; minimizes externalities like traffic congestion; integrates comprehensive planning and revenue strategies. **Cons:** Obligation to spend fee revenue on projects in a timely	3	1	1	3	0	3	3	4	1	2	4

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	manner to benefit fee taxpayer; administrative burden; revenues fluctuate with construction or development market											
Congestion Charges (*28*)	Designed to reduce congestion in peak periods on specific facilities; can be implemented as a cordon charge; area-wide; or variable by facility, time, or congestion level. **Pros:** Location-specific, users directly benefit. **Cons:** Lower-income users will bear a greater proportion of the burden; only suitable for the location with congestion issues	3	2	4	3	0	1	1	3	4	4	2.5
Cordon Pricing (*29*)	A state or locally imposed option whereby drivers can be charged for access to cordoned areas through tolls at certain boundaries or through the sale of passes to drive in the cordoned area. **Pros:** Raise substantial revenues as an option for states and localities; well suited to be dedicated for transportation purposes and can be used flexibly to address different types of transportation needs; can offer strong geographic equity if revenues are spent where they are raised. **Cons:** Not an appropriate means for raising transportation revenues in rural areas with low traffic volumes; significant implementation and administration cost and hurdles; may have no inherent link to the specific investment (little relationship between cordon pricing revenues and system investment decisions); establishing cordon pricing rates that are high enough to achieve demand management goals likely to pose a significant political challenge.	3	1	4	2.5	0	2	2.5	3	4	4	2.5
Container Fees/Tax (*23*)	A national fee imposed on some or all containers moving; levied on freight containers; typically fund freight infrastructure in and around levying port. **Pros:** Raises a decent level of funding relative to freight needs; moderate implementation, administration, and compliance costs; strong sustainability.	3.5	3.5	4	2	0	4	4	4	1	1	3.5

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	Cons: Does little to promote efficient system use; potential international trade law conflicts; could have regional equity issues											
Carbon Taxes (*30*)	User fee based on carbon emissions of fossil fuels; would carry out as an increased fuel tax rate. **Pros:** A carbon tax linked to fuel usage is generally understood by the public; exact carbon content of fossil fuels is known; practiced and well-resulted in other countries. **Cons:** Places Texas fuel retailers in border regions at a competitive disadvantage	2	4.5	3	5	0	2	5	4	3	4	2
Freight Bill (*23*)	A freight waybill tax would serve as a sales tax on the shipping costs for freight. Such a tax could be modeled on the aviation system tax, in which passenger and freight users who rely on the same infrastructure and carriers all contribute to fund the system. The air-freight waybill tax currently provides five percent of contributions to the Federal Airport and Airway Trust Fund. **Pros:** Large revenue yield potential; reasonably equitable. **Cons:** Expensive to administer and enforce; more of an indirect user fee, not as directly related to system use	3	3.5	5	3	0	2	2	2	1	1	3.5
Freight Charge: Ton or Ton-Mile (*23*)	Freight-related taxes could be imposed on a pure tonnage or a ton-mile basis. A ton-based tax would charge shippers a flat fee for every ton of freight moved. Variations of these taxes have been imposed by a few states in the past, but there has not been an equivalent tax imposed at the Federal level. **Pros:** Decent revenue yield potential; justifiable as a transportation user fee; potential positive impact on efficient system use. **Cons:** Strong trucker/rail opposition; the impact of tax heaviest on low-value bulk items; significant implementation,	2	3.5	4	4	0	2	1	1	3.5	1	3.5

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	administration, and compliance issues; not a viable short-term option											
Facility-level Tolling and Pricing (*14*)	Roadway tolling can be applied at the state and local level in a wide range of fashions, including turnpikes, which are individual (generally long-distance) facilities that charge a fee for use; "single links," which are facilities such as bridges, tunnels, or connector roads; and "managed lanes," or highway lanes that are devoted to carpoolers, public transit vehicles, and toll-paying users, including but not limited to high-occupancy toll (HOT) lanes and HOT networks, or systems of high-occupancy vehicle lanes. **Pros:** Generates substantial revenues as an option for states and localities to raise nonfederal shares to pay for state-only investment; dedicated to transportation, especially the facility itself, to compensate for debt service and operations costs; can generate excess revenues that can go toward other transportation improvement; high level of user beneficiary equity if the toll rates reflect the benefits derived by the user; helps maximize the efficiency of the existing network if toll rates are set to manage congestion; tolled turnpikes, where built in regional or national goods movement corridors, can provide highway capacity through rural regions that otherwise could not afford it. **Cons:** Facility-level tolling is not a broad-based means for raising transportation revenues in rural areas with low traffic volumes; strong political and public opposition, especially converting existing facilities to tolled; might produce unfair pricing toward out of region/state users; possible diversion of traffic to less safe, lower-order roads, depending on the toll rates and the condition of alternative routes;	3	2	4	3	1	3	3	4	4	5	3

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	comparatively higher capital and administrative costs for toll collection than non-tolled facilities											
Heavy Vehicle Use Tax (*31*)	An annual fee is currently imposed on all trucks at 55,000 pounds gross vehicle weight (GVW) or greater. The tax rate is $100 plus $22 for each 1,000 pounds of GVW in excess of 55,000 pounds, up to a maximum annual fee of $550 (thus, all trucks with GVW greater than 75,000 pounds pay the maximum). **Pros:** Strong correlation between tax and user benefit/impact; easy and cost-effective to administer. **Cons:** Does not raise a great deal of revenue	3	4	4	2	0	3	4	3	3	4	3
Imported Oil Tax (*32*)	A tax on imported oil charged as either a fixed amount per barrel of oil or as a percentage on the value of imported oil. **Pros:** Small fee could raise significant revenue; can help to promote U.S. energy independence. **Cons:** Broad nature of tax creates limited user pay/benefit relationship (e.g., home heating oil would be taxed for transportation); raises geographical equity issues; could raise broader free trade issues	2	2	2	3.5	0	3	3	4	3	2	2
Sales Tax: Auto-related Parts and Services (*23*)	All states impose annual vehicle registration and related fees. **Pros:** Small tax rate could yield relatively large revenues; strong sustainability; justifiable as a flexible, dedicated source for transportation. **Cons:** Significant administrative and compliance issues; social equity issues; little relationship with system use; limited public acceptance; potential to disincentive repairs and create safety issues	4	4	4	3.5	0	2	2	2	2.5	2	2
Variable Parking Fee (*33*)	Levy a fee on drivers using that parking infrastructure, can vary by time of day. **Pros:** Direct user charges; parking fee set locally according to market to make efficient use of available parking capacity. **Cons:** The variation in ownership of parking facilities	3	2.5	3.5	3.5	0	1	4	4	3	3.5	2

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
	and parking rates from state to state makes it impossible to implement an equitable national surcharge											
Transportation Utility Fee (*20*)	Charge those who benefit in that jurisdiction where infrastructure is built and maintained through a regular (e.g., monthly) utility bill; also known as street maintenance fees, road use fees, street utility fees, and pavement maintenance utility fees. **Pros:** Link cost of maintaining infrastructure coincides with transportation system mobility; doesn't require voter approval. **Cons:** There are legal challenges that question whether it is a fee or a tax	4	5	4.5	1	0	2	3	5	1	3	2
Electric Vehicle Fees (*34*)	A fee specific to electric-type vehicles is levied. This fee can be added to the annual registration fee or as a one-time sales tax. **Pros:** Generate relatively stable revenue streams; relatively easy to administer; improves social equity because EV drivers get to pay a fair amount for using transportation infrastructure. **Cons:** May slow down the rate of adoption of alternatively fueled vehicles; expensive a registration-based fees increase compliance issues	3	3	5	2	0	4	2	4	3.5	5	4
TIFIA (*35*)	The Transportation Infrastructure Finance and Innovation Act (TIFIA) is a federal program that provides credit assistance in the form of secured loans, loan guarantees, and lines of credit for surface transportation projects. The program focuses on large projects of national and regional significance and covers up to 33 percent of eligible project costs. **Pros:** Low interest rates; lowers project risk; helps secure other financing at rates lower than would otherwise be possible. **Cons:** Involves debt; non-sustainable; repayment is required in a short term; minimum project cost requirements; acceptance is not guaranteed	4	4	1	3	1	2	4	4	1	1	1

Mechanism	Description	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	Public Acceptance	Ease of Implementation	Ability to Enforce	Promotion of efficient use	User/ Beneficiary Equity	Promotion of Social Equity
General Obligation Bonds (*36*, *37*)	A debt instrument used by states and local governments. This type of bond commits the government to raise taxes to whatever rate is necessary to repay the debt. These bonds are exempt from federal income tax. **Pros:** Can use any revenues that are at the state's disposal to repay the debt; most creditworthy bonds, relatively low-cost bonds; minimizes reliance on other local, state, and federal governments. **Cons:** Involves debt; requires voter approval; generally operates under legislated bond caps and debt ceilings; relies on specific authorizations that limit the amount of debt outstanding or the amount of new debt allowed	4	4	1	2	1	2	4	2	1	1	1
Revenue Bonds (*36–38*)	Revenue bonds are repaid from funds generated by a specific revenue source or a dedicated tax in the area the investment will serve. **Pros:** Minimizes reliance on other local, state, and federal governments; relatively low-cost bonds. **Cons:** Involves debt; requires the commitment of future revenues by local borrowers as well as other local commitments to satisfy borrowing requirements and debt servicing	4	4	1	2	1	2	4	2	1	1	1
Private Activity Bonds (*36*, *39*)	Debt instruments are issued by state or local governments, the proceeds of which are used to construct projects with significant private involvement. In this case, the state or local government serves as a conduit providing financing to nongovernmental persons. PABs are generally not eligible for federal tax exemption. **Pros:** Minimizes reliance on other local, state, and federal governments; relatively lower interest rates. **Cons:** Involves debt; federal limit on the total dollar amount per state and per capita that can be issued	4	4	1	2	1	2	4	2	1	1	1

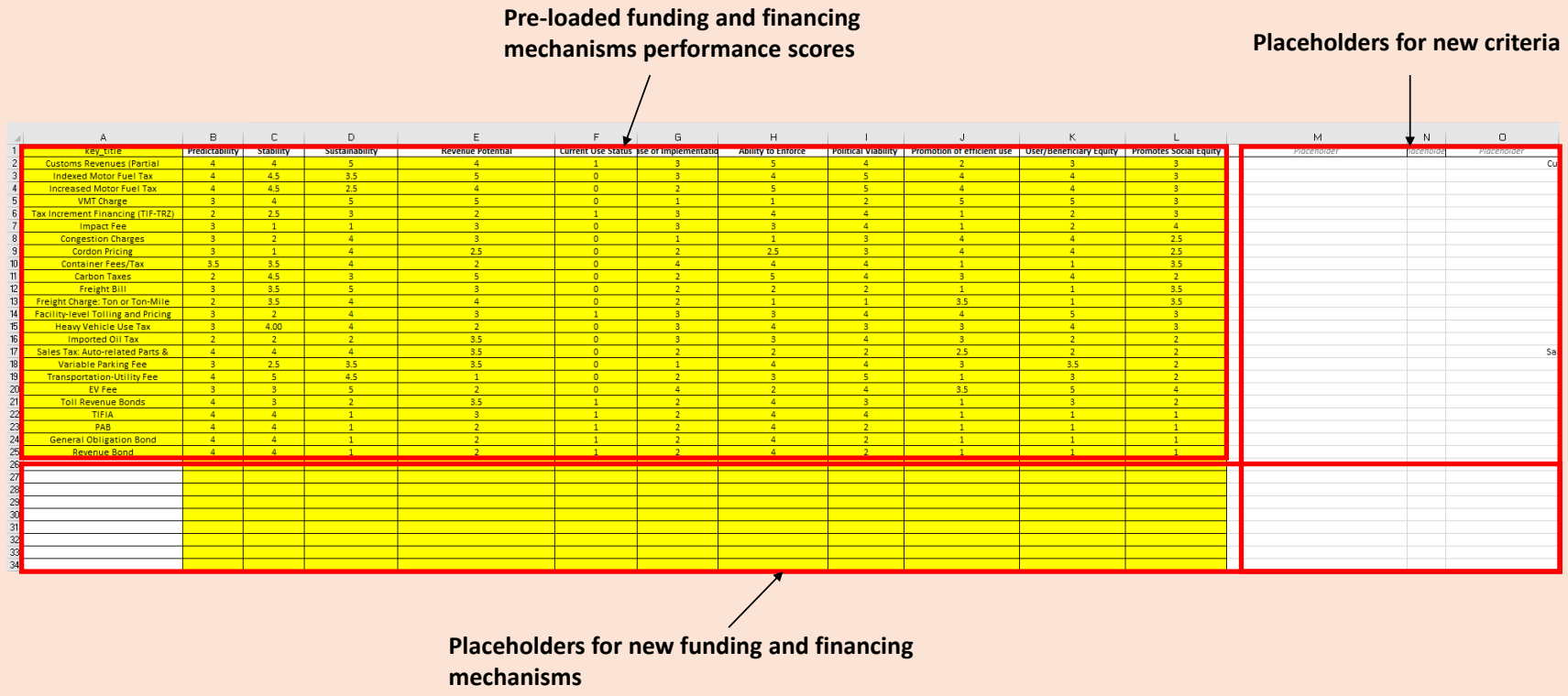
Exhibit 4-1 Excel Implementation of funding/financing mechanisms performance scores

Refer to the `ahp_final.xlsx` Excel workbook for the implementation of the funding/financing mechanisms performance scores (the output of the "Problem Structuring" block of **Figure** 4-5). The scores of the alternatives over each criterion, as previously introduced in **Table 4-3**, are presented in the "Mechanism_Matrix" Sheet (cells A1:L25).

Blank cells here serve as placeholders, allowing for the potential addition of other financing mechanisms to the analysis (cells A26:A34). Additionally, placeholders are also made available for additional decision criteria to allow the users to integrate future expansions to the decision framework (cells M2:O34). The blank placeholders alongside the pre-loaded performance scores are shown in **Figure 4-7**.

The first step involves normalizing the scores from a zero-to-five scale to a zero-to-one scale (cells Q1:AE:34). Then the sheet updates automatically to perform the pairwise comparisons for each criterion separately. The pairwise comparisons are implemented in cells A36:AD612. Columns A and B of this range include all possible pairings of mechanisms. Then in Columns C through P, a lookup function is executed to look for the normalized scores of each mechanism for each criterion (from cells Q1:AE:34) then subtract the two scores. Columns Q through AD, convert the differences to AHP scale as presented in **Table 4-8**.

Finally, the matrix located in AH1:AW34 represents the score of each financing mechanism with respect to each criterion.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Key_title	Predictability	Stability	Sustainability	Revenue Potential	Current Use Status	se of Implementatio	Ability to Enforce	Political Viability	Promotion of Efficient Use	User/Beneficiary Equity	Promotes Social Equity	Placeholder	Placeholder	Placeholder
2	Customs Revenues (Partial	4	4	5	4	1	3	5	4	2	3	3			Cu
3	Indexed Motor Fuel Tax	4	4.5	3.5	5	0	3	4	5	4	4	3			
4	Increased Motor Fuel Tax	4	4.5	2.5	4	0	2	5	5	4	4	3			
5	VMT Charge	3	4	5	5	0	1	1	2	5	5	3			
6	Tax Increment Financing (TIF-TRZ)	2	2.5	3	2	1	3	4	4	1	2	3			
7	Impact Fee	3	1	1	3	0	3	3	4	1	2	4			
8	Congestion Charges	3	2	4	3	0	1	1	3	4	4	2.5			
9	Cordon Pricing	3	1	4	2.5	0	2	2.5	3	4	4	2.5			
10	Container Fees/Tax	3.5	3.5	4	2	0	4	4	4	1	1	3.5			
11	Carbon Taxes	2	4.5	3	5	0	2	5	4	3	4	2			
12	Freight Bill	3	3.5	5	3	0	2	2	2	1	1	3.5			
13	Freight Charge: Ton or Ton-Mile	2	3.5	4	4	0	2	1	1	3.5	1	3.5			
14	Facility-level Tolling and Pricing	3	2	4	3	1	3	3	4	4	5	3			
15	Heavy Vehicle Use Tax	3	4.00	4	2	0	3	4	3	3	4	3			
16	Imported Oil Tax	2	2	2	3.5	0	3	3	4	3	2	2			
17	Sales Tax: Auto-related Parts &	4	4	4	3.5	0	2	2	2	2.5	2	2			Sa
18	Variable Parking Fee	3	2.5	3.5	3.5	0	1	4	4	3	3.5	2			
19	Transportation-Utility Fee	4	5	4.5	1	0	2	3	5	1	3	2			
20	EV Fee	3	3	5	2	0	4	2	4	3.5	5	4			
21	Toll Revenue Bonds	4	3	2	3.5	1	2	4	3	1	3	2			
22	TIFIA	4	4	1	3	1	2	4	4	1	1	1			
23	PAB	4	4	1	2	1	2	4	2	1	1	1			
24	General Obligation Bond	4	4	1	2	1	2	4	2	1	1	1			
25	Revenue Bond	4	4	1	2	1	2	4	2	1	1	1			
26															
27															
28															
29															
30															
31															
32															
33															
34															

Figure 4-7 Funding/Financing Mechanism Performance Scores and Placeholders

4.3.2.2. Project Characteristics

This section involves the prerequisites for the AHP implementation. It involves extracting the project characteristics and correlating that with the level of importance of the decision criteria. Since the aim of the FUND database is to automatically relate project characteristics to criteria importance, it was essential to investigate the relationship between project characteristics scores and the decision criteria (*1*).

The Project Characteristics block of **Figure** 4-5 outlines the methodology for calculating decision criteria scores from project characteristics.

Questions and answers (the top box within the "Project Characteristics" block of **Figure** 4-5) reflects the project questionnaire within FUND that asks the user a series of questions (refer to **Figure 4-2** for the list of questions). Many of the answers offered are categorical (mostly ordered, such as low/medium/high), and map to a set of points that can be assigned to project characteristics (*1*).

Project characteristics scores (the middle box within the project characteristics block of **Figure** 4-5) are designed to group the project question answers into a smaller set of coherent variables, capturing the major features of the project that could be related to the selection of financing mechanisms (*1*). Due to the nature of the definition, the project characteristic scores (PCS) are a function of project answers (one-to-multiple relationship). For example, "How long is the project construction period?" would indicate whether the project involves "long-term investment" and has a "large project scale." The current set of Project Characteristics *K* includes:

- Large Project Scale
- Exact Investment Timing
- Long-term Investment
- High Significance
- Innovation
- Project Sustainability Goals
- Project Equity Goals

The set of answers *A* is converted to *K* individual PCS using Equation (6).

$$p_k = \sum_{a \in A} w_{ak} \tag{6}$$

where

- w_{ak} are the weights used for each transformation of the answer *a* to project characteristic *k*
- *A* is the set of all answers
- p_k is the cumulative score for characteristic *k.*

An example of w_{ak} values for the project budget question is presented in **Figure 4-8** below. Also, an illustration of the calculations provided in Equation (1) is presented in **Figure 4-9**. **Figure 4-9** is a screenshot of the `ahp_final.xlsx` Excel workbook; please refer to that file for more details regarding the calculation of PCS.

Exhibit 4-2 Excel Implementation of funding/financing mechanisms performance scores

Refer to the `ahp_final.xlsx` Excel workbook and the AHP_sym or AHP_average sheet for the implementation of Questions and answers and Project characteristics scores processes described previously (within "Project Characteristics" block of **Figure** 4-5).

An example of w_{ak} values for the project budget question is presented in **Figure 4-8** below for the Project Budget Question. Also, an illustration of the calculations provided in Equation (1) is presented in **Figure 4-9**. **Figure 4-9** is a screenshot of the Excel workbook (cells A1:X72), please refer to that file for more details regarding the calculation of PCS. Columns I through K are left as placeholders for additional project characteristics categories. The computed project characteristics scores are shown in cells A71:K72. Column M integrates the answers provided in the main sheet to calculate the project characteristics scores. The Answers column is set to 0 if that answer was not selected by the user and to 1 if the user selects that option.

1 **w_{ak}, the wights used to transform each of the Project Budget Answers to each project characteristic**

Budget	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
Millions	0	0	0	0	0	0	0
10 million	1	0	0	0.5	0	0	0
100 million	2	1	0	1	0	0	0
Billions	3	2	0	2	0	0	0

2 **Select Billions as an answer "a" for the Project Budget, for example**

Figure 4-8 Project Characteristics Calculate for each Question, Such as Project Budget

1 **Multiply w_{ak} with the corresponding answer**

Budget	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
Millions	0	0	0	0	0	0	0
10 millions	1	0	0	0.5	0	0	0
100 millions	2	1	0	1	0	0	0
Billions	3	2	0	2	0	0	0
Construction Period	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
less than 1 year	0	0	0	0	0	0	0
1-2 years	0	0	0	0	0	0	0
3-5 years	0.5	0	1	0	0	0	0
More than 5 years	1	-1	2	0	0	0	0
TxDOT Investment Time	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
2	0	3	-1	2	0	0	0
4	0	1	0	1	0	0	0
10	0	0	2	0	0	0	0
50	0	0	3	0	0	0	0
Project Priority	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
Low	0	0	0	0	0	0	0
Medium	0	0	0	1	0	0	0
High	0	2	0	2	0	0	0
Innovation	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
No	0	0	0	0	0	0	0
Yes	0	0	0	0	1	0	0
Equity Goals	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
No	0	0	0	0	0	0	0
Yes	0	0	0	0	0	0	1
Sustainability Goals	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
No	0	0	0	0	0	0	0
Yes	0	0	0	0	0	1	0
Business Density	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
Low	0	0	0	0	0	0	0
Medium	0	0	0	0.2	0	0	0
High	0	1	0	0.5	0	0	0

Project Characteristics	Large Project Scale	Exact Investment Timing	Long-term Investment	Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
Project Characteristics Score	SUM(L4:L54)	5	1	5.2	0	0	1

Answers	Large Project Scale	Exact Investment Timing	Long-term Investment	High Significance	Innovation	Sustainable Project	Equity Conscious Project/ Department
0	$J4*B4	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	3	2	0	2	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0.5	0	1	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0	2	0	2	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0	0	0	0.2	0	0	0
0	0	0	0	0	0	0	0

2 **Sum all the weights for each characteristic K over all the answers to obtain the Project Characteristics Score (PCS)**

Figure 4-9 Illustration of the Calculation of Project Characteristics Scores (PCS)

The natural next step is relating the PCS to the importance of each decision criterion. To establish a relationship between the continuous p_k (refer to **Figure 4-9** for PCS examples) and criteria importance, four reference project examples (the top oval within the "Project Characteristics" block of **Figure** 4-5) were considered, each of which helps to display extreme characteristics so one can determine how each criterion is connected to each of the characteristics. The project profiles were carefully designed in collaboration with TxDOT to cover a comprehensive set of project characteristics commonly encountered. The characteristics corresponding to different project scenarios were summarized previously in **Table 4-1**. For instance, Project #1 is a large project, with a strict budget, long-term investment, and long construction phase (*1*).

For each project profile, the PCS are calculated based on the relevant answers, as shown in **Figure 4-9**. Then, each criterion's importance is specified based on the experience of the research team and the literature. Consequently, each of the seven project characteristics will have importance scores for each of the eleven decision criteria. Ultimately, four matrices that show the reference decision criteria score (the bottom oval within the "Project Characteristics" block of Figure 4-5) for each project profile are determined (*1*).

Table 4-4 shows the project characteristics and criteria importance scores for Project Profile 1. For example, predictability receives a score of 5 when examined against the large project scale characteristic while it receives a score of 3 for the sustainability criteria because it is a medium-term investment. **Table 4-5**, **Table 4-6**, and **Table** 4-7 present the project characteristics and criteria importance scores for Project Profiles 2, 3, and 4; respectively.

The reference decision criteria scores, such as those presented in **Table 4-4**, **Table 4-5**, **Table 4-6**, and **Table** 4-7, can be elicited from transportation experts through a Delphi survey. In each question in the survey, the decision-maker assigns a numerical value to the dominant factor that reflects its importance based on specific project characteristics. Since the Delphi survey had not been conducted at the time of this writing, the authors filled those matrices based on their knowledge, meetings with DOT experts, and the literature on the topic (*1*). A sample survey that can achieve those objectives was designed by the research team and is presented in **Appendix B**.

The same process is replicated for the three remaining reference projects to achieve **Figure 4-11** which shows the change in the criteria importance score as a function of the PCS corresponding to each of the considered characteristics.

Exhibit 4-3 Excel Implementation of project characteristics and decision importance scores

Refer to the `ahp_final.xlsx` Excel workbook and the Interpolation sheet for the implementation of reference decision criteria score (the bottom oval within the "Project Characteristics" block of **Figure** 4-5) for each project profile are determined.

The interpolation sheet is populated using the project characteristics score and criteria importance score values of **Table 4-5**, **Table 4-6**, and **Table 4-7**. The sheet has six columns: project characteristics, decision criteria, a unique identifier (combination of project characteristics and decision criteria), characteristic scores, criteria scores, and Direction (refer to **Figure 4-10**). The direction column is set to I if the relationship in **Figure 4-11** is increasing and D if decreasing.

Similar to the Mechanism_matrix sheet, placeholders are available in both the characteristics and criteria columns to allow users to readily incorporate additions (refer to **Figure 4-10** cells B8:B35).

	A	B	C	D	E	F
1	Characteristic	Criteria	UNQ	Characteristic_sco	Criteria Sco	Directi
2	Equity Conscious Project/ D	Ability to Enforce	Equity Conscious Project/ Department-Ability to Enforce	0	0	I
3	Equity Conscious Project/ D	Ability to Enforce	Equity Conscious Project/ Department-Ability to Enforce	1	0	I
4	Equity Conscious Project/ D	Current Use Status	Equity Conscious Project/ Department-Current Use Status	0	0	I
5	Equity Conscious Project/ D	Current Use Status	Equity Conscious Project/ Department-Current Use Status	1	0	I
6	Equity Conscious Project/ D	Ease of Implementation	Equity Conscious Project/ Department-Ease of Implementation	0	0	I
7	Equity Conscious Project/ D	Ease of Implementation	Equity Conscious Project/ Department-Ease of Implementation	1	0	I
8	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
9	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
10	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
11	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
12	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
13	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
14	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
15	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
16	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
17	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
18	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
19	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
20	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
21	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	0		I
22	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
23	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
24	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
25	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
26	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
27	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
28	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
29	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
30	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
31	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
32	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
33	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
34	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I
35	Equity Conscious Project/ D	Placeholder	Equity Conscious Project/ Department-Placeholder	1		I

Figure 4-10 Excel Layout of Interpolation Sheet

The relationships established in **Figure 4-11** are leveraged to automatically relate project characteristics to criteria importance within FUND through the Interpolation of decision criteria scores (the bottom box within the "Project Characteristics" block of **Figure** 4-5). For example, if a new project being studied has a "Large Project Scale" score of 1.5, then the characteristic scores of the four project profiles are used to obtain the upper and lower limit values and determine the required criteria importance scores via linear interpolation, as shown in Equation (7).

$$\text{Criteria Score} = \text{Criteria Score}_{lb} + \frac{(\text{CS} - \text{CS}_{lb})}{(\text{CS}_{ub} - \text{CS}_{lb})} \times (\text{Criteria Score}_{ub} - \text{Criteria Score}_{lb}) \qquad (7)$$

where CS represents characteristic scores at respective upper bound *ub* and lower bound *lb*.

The outcome of the "Project Characteristics" component is the Decision criteria scores (the output of the "Project Characteristics" block of **Figure** 4-5) corresponding to each criterion and calculated by averaging the non-zero cells of each row in the criteria importance scores matrix (refer to **Table 4-4**, **Table 4-5**, **Table 4-6**, and **Table** 4-7). Equation (8) below presents the latter computation (*1*).

$$Avg.imp.score_i = \frac{\sum_{k=1}^{N} Imp.score_{ik}}{N} \qquad (8)$$

where $N = 7$ is the number of project characteristics considered.

Table 4-4 Project Characteristics and Criteria Importance Scores for Project Profile 1 (*1*)

Project Characteristics	Large Project Scale	Exact Investment Timing	Long-term Investment	Significance	Innovation	Sustainable Project	Equity Conscious Project
Project Characteristics Score	3.5	5	1	5.2	0	0	1
Decision Criteria	**Criteria Importance Score (Scale 0-5)**						
	Large Project Scale	**Exact Investment Timing**	**Long-term Investment**	**Significance**	**Innovation**	**Sustainable Project**	**Equity Conscious Project**
Predictability	5	4	0	4	0	0	0
Stability	4	5	0	4	0	0	0
Sustainability	0	0	3	0	0	0	0
Revenue Potential	5	0	0	0	0	0	0
Current Use Status	0	2	0	2	0	0	0
Ease of Implementation	0	0	0	0	0	0	0
Ability to Enforce	0	0	0	0	0	0	0
Public Acceptance	0	0	0	0	0	0	0
Promotion of Efficient Use	0	0	0	0	0	1	0
User/Beneficiary Cost	0	0	0	0	0	1	3
Promotion of Social Equity	0	0	0	0	0	0	4

Table 4-5 Project Characteristics and Criteria Importance Scores for Project Profile 2

Project Characteristics	Large Project Scale	Exact Investment Timing	Long-term Investment	Significance	Innovation	Sustainable Project	Equity Conscious Project
Project Characteristics Score	2	4	0	4.2	1	1	1
Decision Criteria	**Criteria Importance Score (Scale 0-5)**						
	Large Project Scale	**Exact Investment Timing**	**Long-term Investment**	**Significance**	**Innovation**	**Sustainable Project**	**Equity Conscious Project**
Predictability	4	4	0	3.5	0	0	0
Stability	3	5	0	3.5	0	0	0
Sustainability	0	0	3	0	0	0	0
Revenue Potential	4	0	0	0	0.5	0	0
Current Use Status	0	2	2	3	0	0	0

Ease of Implementation	1	2	1	1	0	0	0
Ability to Enforce	1	0	0	1	0	0	0
Public Acceptance	1	0	0	1	0	0	0
Promotion of Efficient Use	0	0	0	0	1	4	0
User/Beneficiary Cost	0	0	0	0	0.5	2.5	3
Promotion of Social Equity	0	0	0	0	0.5	1.5	4

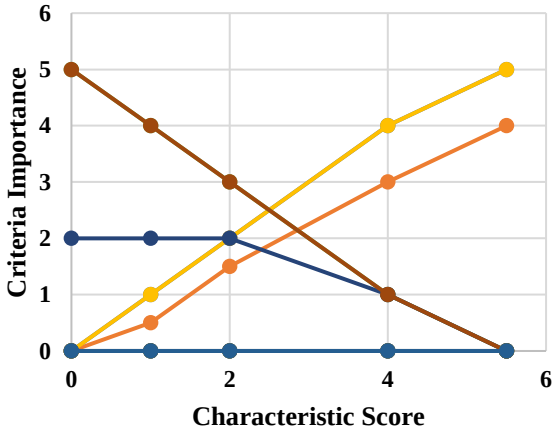
Table 4-6 Project Characteristics and Criteria Importance Scores for Project Profile 3

Project Characteristics	**Large Project Scale**	**Exact Investment Timing**	**Long-term Investment**	**Significance**	**Innovation**	**Sustainable Project**	**Equity Conscious Project**
Project Characteristics Score	1	4	-1	3	0	1	1
Decision Criteria	**Criteria Importance Score (Scale 0-5)**						
	Large Project Scale	**Exact Investment Timing**	**Long-term Investment**	**Significance**	**Innovation**	**Sustainable Project**	**Equity Conscious Project**
Predictability	2	4	0	2.5	0	0	0
Stability	1.5	5	0	2.5	0	0	0
Sustainability	0	0	0	0	0	0	0
Revenue Potential	2	0	0	0	0	0	0
Current Use Status	0	2	4	3.5	0	0	0
Ease of Implementation	3	2	3	2	0	0	0
Ability to Enforce	2	0	0	1	0	0	0
Public Acceptance	3	0	2	2	0	0	0
Promotion of Efficient Use	0	0	0	0	0	4	0
User/Beneficiary Cost	0	0	0	0	0	2.5	3
Promotion of Social Equity	0	0	0	0	0	1.5	4

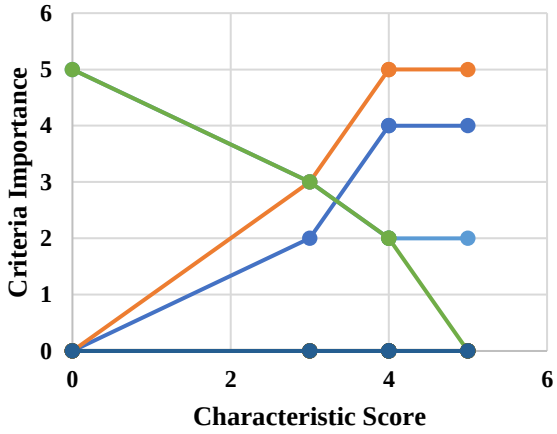
Table 4-7 Project Characteristics and Criteria Importance Scores for Project Profile 4

Project Characteristics	Large Project Scale	Exact Investment Timing	Long-term Investment	Significance	Innovation	Sustainable Project	Equity Conscious Project
Project Characteristics Score	0	3	-1	2	0	0	1
Decision Criteria	**Criteria Importance Score (Scale 0-5)**						
	Large Project Scale	**Exact Investment Timing**	**Long-term Investment**	**Significance**	**Innovation**	**Sustainable Project**	**Equity Conscious Project**
Predictability	1	2	0	1	0	0	0
Stability	0.5	3	0	1	0	0	0
Sustainability	0	0	0	0	0	0	0
Revenue Potential	1	0	0	0	0	0	0
Current Use Status	0	3	4	4	0	0	0
Ease of Implementation	4	3	3	3	0	0	0
Ability to Enforce	2	0	0	1	0	0	0
Public Acceptance	4	0	2	3	0	0	0
Promotion of Efficient Use	0	0	0	0	0	1	0
User/Beneficiary Cost	0	0	0	0	0	1	3
Promotion of Social Equity	0	0	0	0	0	0	4

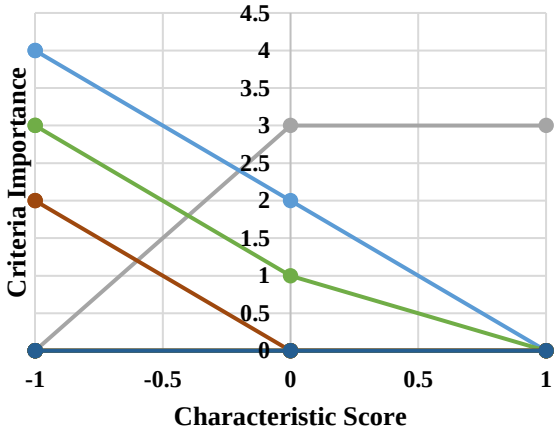
(a) Large Project



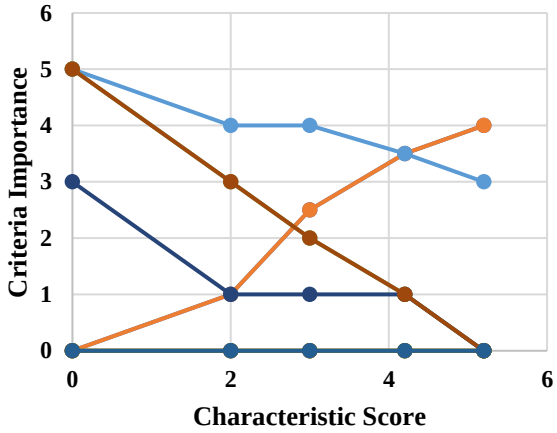
(b) Exact Investment



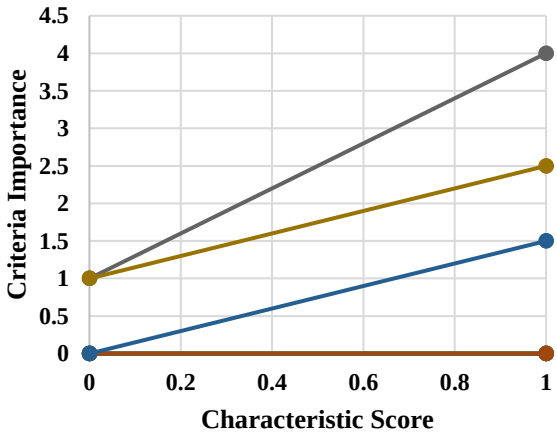
(c) Long-Term Investment



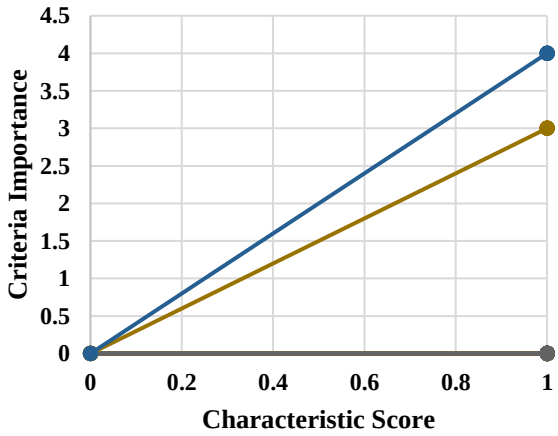
(d) Significance



(e) Sustainability



(f) Equity



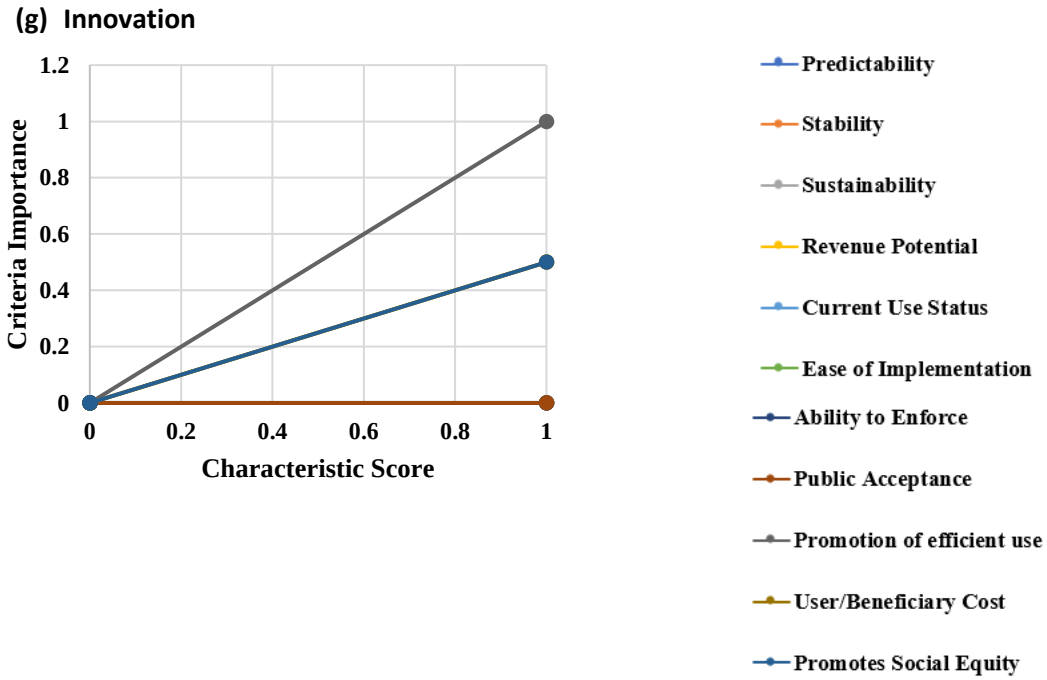


Figure 4-11 Criteria Importance Scores as a Function of Characteristic Scores for: a) Large project, b) Exact investment timing, c) Long-term investment, d) Significance, e) Sustainability, f) Equity, and g) Innovation (*1*)

4.3.3. AHP Calculations

The AHP calculations in **Figure** 4-5 are conducted to rank the funding/financing mechanisms. The decision criteria importance scores are converted to pairwise comparisons (the top box within the "AHP Calculations" block of **Figure** 4-5) to make them compatible with the AHP framework computations. This conversion is implemented as follows.

The difference between the average criteria importance scores (that were calculated using Equation 3) is calculated in a pairwise fashion, as presented in Equation (9).

$$\text{Absolute difference}_{ij} = \left|Avg.imp.score_i - Avg.imp.score_j\right| \quad (9)$$

Finally, the differences are converted to Saaty's 1–9 scale for pairwise comparisons according to their magnitude, as shown in **Table** 4-8. For example, an absolute difference of magnitude less than 0.15 is translated into a value of 1 on the AHP scale.

Table 4-8 Conversion from absolute difference to Saaty's Scale of Relative Importance

Absolute difference	1-9 Scale	Verbal Definition
0.0 - 0.15	1	Equal Importance
0.15 - 0.3	2	Weak Importance
0.3 - 0.4	3	Moderate Importance
0.4 - 0.5	4	Moderate Plus
0.5 - 0.6	5	Strong Importance
0.6 - 0.7	6	Strong Plus
0.7 - 0.8	7	Very Strong Importance
0.8 - 0.9	8	Very, Very Strong Importance
0.9 - 1.0	9	Extreme Importance
If the difference is < 0	Reciprocal ($a_{ij}=1/a_{ji}$)	

Following these steps, a pairwise comparison matrix for the decision criteria is determined and used to calculate the priority vector (or Eigenvector) (refer to the references provided in the MCDA and AHP Concept section for calculation details). The priority vector (the bottom box within the "AHP Calculations" block of **Figure** 4-5) shows the weights of the criteria while deciding on the most appropriate financing mechanism (*1*). The criteria weights are then combined with the financing mechanism.

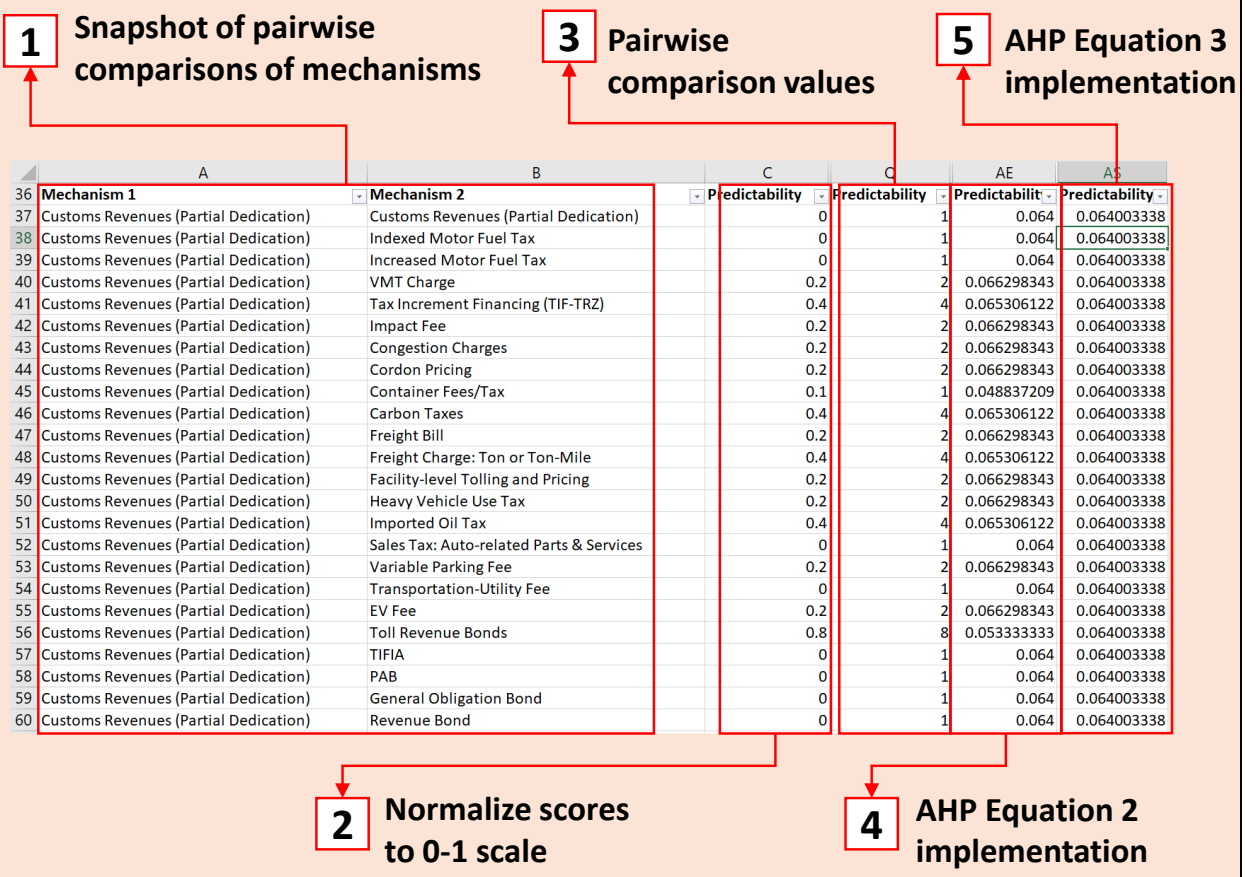
The criteria weights are combined with the financing mechanism alternative scores to obtain the global scores and final ranking of alternatives based on appropriateness. The ranking, in this case, is a function of the project characteristics that affect the weight given to the different decision criteria. (*1*)

Exhibit 4-4 Excel Implementation of pairwise comparisons and priority vector calculations

Refer to the `ahp_final.xlsx` Excel workbook for the implementation of the pairwise comparisons and priority vector calculations (refer to "AHP Calculations" block of Figure 4-5).

This process is done separately for the funding/financing mechanisms in the Mechanism_matrix sheet and the decision criteria in AHP_sum and AHP_average sheets.

In the "Mechanism_Matrix" Sheet, the first step involves normalizing the scores from a zero-to-five scale to a zero-to-one scale (cells Q1:AE:34). Then the sheet updates automatically to perform the pairwise comparisons for each criterion separately. The pairwise comparisons are implemented in cells A36:AD612. Columns A and B of this range include all possible pairings of mechanisms. Then in Columns C through P, a lookup function is executed to look for the normalized scores of each mechanism for each criterion (from cells Q1:AE:34) then subtract the two scores. Columns Q through AD, convert the differences to AHP scale using the conversion scale presented in **Table 4-8**. Cells AE36:BF612 implement AHP calculations to calculate the priority vectors for all the mechanisms on each individual criterion. In particular, columns AE till AQ perform Equation (2), and columns AR to BF perform Equation (3) that were presented previously. **Figure 4-12** shows the steps for normalizing the scores (Step 2), pairwise comparisons (Step 3), and priority vector calculation (Steps 4 and 5) for the funding and financing mechanisms. The figure only shows the columns associated with the predictability criterion for simplicity. Finally, the matrix located in AH1:AW34 represents the score of each financing mechanism with respect to each criterion based on the values obtained from Step 5 of **Figure 4-12**.



	A	B	C	C	AE	AS
36	**Mechanism 1**	**Mechanism 2**	**Predictability**	**Predictability**	**Predictabilit**	**Predictability**
37	Customs Revenues (Partial Dedication)	Customs Revenues (Partial Dedication)	0	1	0.064	0.064003338
38	Customs Revenues (Partial Dedication)	Indexed Motor Fuel Tax	0	1	0.064	0.064003338
39	Customs Revenues (Partial Dedication)	Increased Motor Fuel Tax	0	1	0.064	0.064003338
40	Customs Revenues (Partial Dedication)	VMT Charge	0.2	2	0.066298343	0.064003338
41	Customs Revenues (Partial Dedication)	Tax Increment Financing (TIF-TRZ)	0.4	4	0.065306122	0.064003338
42	Customs Revenues (Partial Dedication)	Impact Fee	0.2	2	0.066298343	0.064003338
43	Customs Revenues (Partial Dedication)	Congestion Charges	0.2	2	0.066298343	0.064003338
44	Customs Revenues (Partial Dedication)	Cordon Pricing	0.2	2	0.066298343	0.064003338
45	Customs Revenues (Partial Dedication)	Container Fees/Tax	0.1	1	0.048837209	0.064003338
46	Customs Revenues (Partial Dedication)	Carbon Taxes	0.4	4	0.065306122	0.064003338
47	Customs Revenues (Partial Dedication)	Freight Bill	0.2	2	0.066298343	0.064003338
48	Customs Revenues (Partial Dedication)	Freight Charge: Ton or Ton-Mile	0.4	4	0.065306122	0.064003338
49	Customs Revenues (Partial Dedication)	Facility-level Tolling and Pricing	0.2	2	0.066298343	0.064003338
50	Customs Revenues (Partial Dedication)	Heavy Vehicle Use Tax	0.2	2	0.066298343	0.064003338
51	Customs Revenues (Partial Dedication)	Imported Oil Tax	0.4	4	0.065306122	0.064003338
52	Customs Revenues (Partial Dedication)	Sales Tax: Auto-related Parts & Services	0	1	0.064	0.064003338
53	Customs Revenues (Partial Dedication)	Variable Parking Fee	0.2	2	0.066298343	0.064003338
54	Customs Revenues (Partial Dedication)	Transportation-Utility Fee	0	1	0.064	0.064003338
55	Customs Revenues (Partial Dedication)	EV Fee	0.2	2	0.066298343	0.064003338
56	Customs Revenues (Partial Dedication)	Toll Revenue Bonds	0.8	8	0.053333333	0.064003338
57	Customs Revenues (Partial Dedication)	TIFIA	0	1	0.064	0.064003338
58	Customs Revenues (Partial Dedication)	PAB	0	1	0.064	0.064003338
59	Customs Revenues (Partial Dedication)	General Obligation Bond	0	1	0.064	0.064003338
60	Customs Revenues (Partial Dedication)	Revenue Bond	0	1	0.064	0.064003338

Figure 4-12 Pairwise comparisons and Priority vector calculations for funding/financing mechanisms

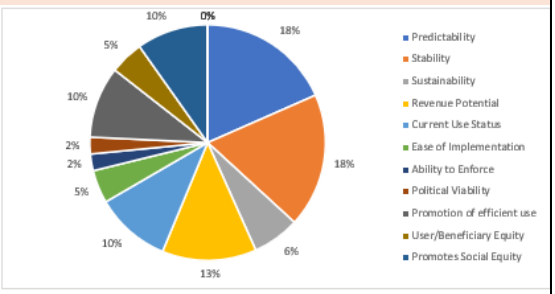
Similar steps are also done in the AHP_sum and AHP_average sheets for the criteria.
The AHP_sum sheet mostly involves the AHP calculations. The first step is normalizing the sum of criteria importance score by dividing it by the maximum sum value (cells A96:C114). The differences between each criteria pairs are calculated (cells A118:O133) and converted to Saaty's nine-level scale to obtain the pairwise comparison matrix (cells A139:O153). Then the priority vector (or Eigenvector) is calculated as discussed in the theoretical section on AHP in cells A159:P:173. Based on the AHP approach, the weights of each criterion are determined (cells P159:P173). If there is a need to override the calculated weights, users can specify new weights based on their preferences in cells P159:P173. Finally, based on the results of the Mechanism_matrix sheet and the criteria weights, the appropriateness scores for the financing mechanisms are computed and the alternatives are ranked accordingly (cells A181:Q210). Similar to the previous sheets, placeholder cells are maintained for future workbook maintenance and expansion.

The AHP_average sheet features the same operations and matrices as the AHP_sum sheet except for aggregating the criteria scores across cells A96:C114. Instead of summing the criteria importance scores, they are averaged and then normalized. This computation was performed because the summation methodology tends to be biased towards the criteria that are affected by several project characteristics. On the contrary, the average methodology tends to put more weight on criteria that are only featured in a few project characteristics. Therefore, the final criteria weights and the financing mechanisms scores presented in the MAIN sheet include the average results from the AHP_sum and

AHP_average sheets. The final results are summarized in the MAIN sheet as presented in **Figure 4-13**. Note that this summary is what appears after clicking the details button in the FUND application.

Budget	Answers
<Million	0
Millions	0
100 millions	0
Billions	1
Construction Period	
less than 1 year	0
1-3 years	1
3-5 years	0
More than 5 years	0
TxDOT Investment Time	
2	0
4	1
10	0
50	0
Project Priority	
Low	0
Medium	1
High	0
Innovation	
No	1
Yes	0
Equity Goals	
No	0
Yes	1
Sustainability Goals	
No	0
Yes	1
Business Density	
Low	0
Medium	1
High	0

Criteria	Weight
Predictability	18%
Stability	18%
Sustainability	6%
Revenue Potential	13%
Current Use Status	10%
Ease of Implementation	5%
Ability to Enforce	2%
Political Viability	2%
Promotion of efficient use	10%
User/Beneficiary Equity	5%
Promotes Social Equity	10%
Placeholder	0%
Placeholder	0%
Placeholder	0%



Mechanism	Score	Rank
Customs Revenues (Partial Dedication)	6.50%	4
Indexed Motor Fuel Tax	7.38%	1
Increased Motor Fuel Tax	6.58%	3
VMT Charge	6.94%	2
Tax Increment Financing (TIF-TRZ)	3.48%	18
Impact Fee	3.61%	17
Congestion Charges	4.05%	14
Cordon Pricing	3.85%	16
Container Fees/Tax	4.67%	11
Carbon Taxes	5.60%	5
Freight Bill	4.33%	13
Freight Charge: Ton or Ton-Mile	4.47%	12
Facility-level Tolling and Pricing	5.08%	8
Heavy Vehicle Use Tax	4.83%	10
Imported Oil Tax	3.30%	19
Sales Tax: Auto-related Parts & Services	5.04%	9
Variable Parking Fee	3.97%	15
Transportation-Utility Fee	5.48%	6
EV Fee	5.45%	7
Toll Revenue Bonds	1.08%	20
TIFIA	1.08%	20
PAB	1.08%	20
General Obligation Bond	1.08%	20
Revenue Bond	1.08%	20
0	#N/A	#N/A
0	#N/A	#N/A
0	#N/A	#N/A
0	#N/A	#N/A
0	#N/A	#N/A

Figure 4-13 Excel main screen showing project-related inputs and appropriateness outputs

4.4. Viewing Funding/Financing Mechanisms Directly

To view all of the funding and financing mechanisms directly as they are represented in the database, it is possible to use the Microsoft Access user interface to view the relevant tables.

On the left pane, double-click on the “mechanisms” entry under the “Tables” heading. This will display the titles and descriptions for each funding and financing mechanism. Each of these is referenced by a unique, shorthand code that starts with “m_”.

5. PROJECTIONS MODULE

While the Appropriateness module is built to match funding and financing types, the Projections module is constructed to estimate the availability of funding sources. This section describes the Projections module's workings.

5.1. Navigating the User interface

5.1.1. Main Page

The first step involves navigating to the start page of the user selects "Projections". Then, the user selects a specific economic scenario that best fits the project at hand from the dropdown menu, as shown under Step 1 in **Figure 5-1**. These scenarios include the following options:

- Good Economy, large increase in fees
- Good Economy, minimal fees
- Good Economy, no new fees
- Poor Economy, large increase in fees
- Poor Economy, minimal fees
- Poor Economy, no new fees
- Default

If none of the scenarios fits the economic landscape, select the "Default" scenario at this step and the software will allow updating the pre-loaded scenarios or creating a new scenario on the next page. To transfer from the main page to the inputs page click the "Go" button, as shown under Step 2 in **Figure 5-1**.

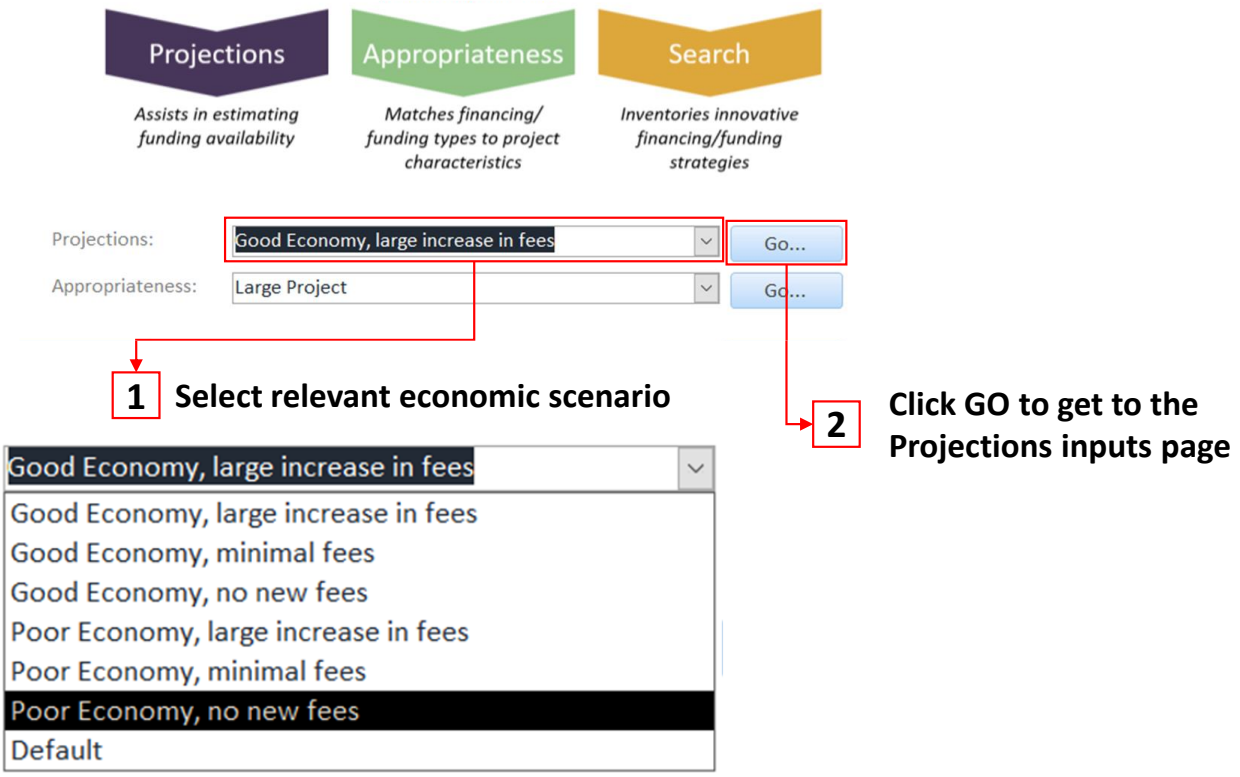


Figure 5-1 Projections Scenario Selection Menu

5.1.2. Inputs Page

After the Go button is clicked on the main page, an Inputs page appears for the Projections, as shown in Figure 5-2.

The first step on this page is selecting the correct scenario and adjust any incorrect ones. On the top of the screen (refer to Step 1 within Figure 5-2) is the mechanism for selecting, creating, and saving scenarios.

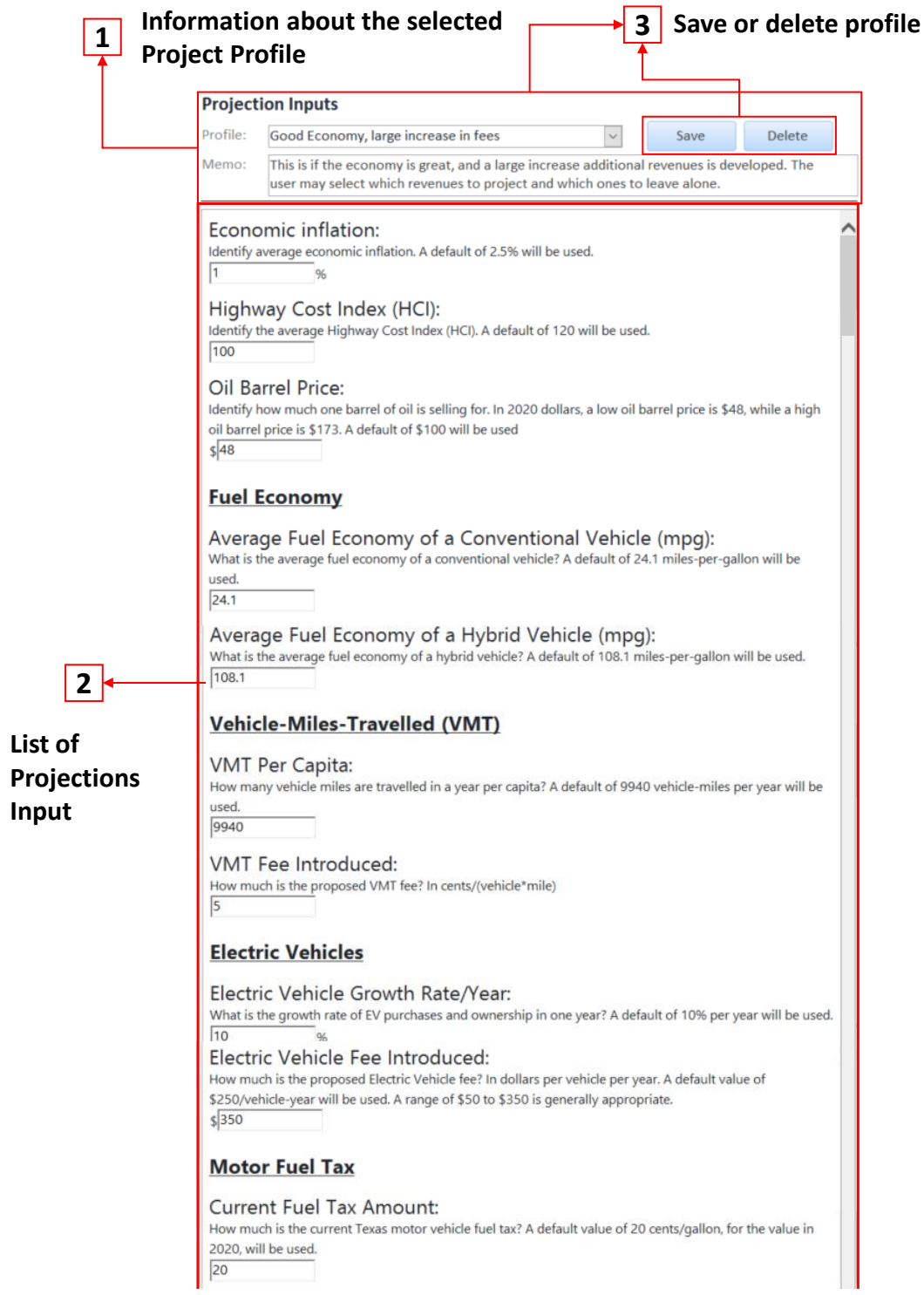
Each scenario may have a memo associated with it to help distinguish its purpose. Additionally, each scenario corresponds to a set of inputs that get loaded into the Inputs Page. For example, Figure 5-2 shows the pre-loaded inputs for the "Good Economy, no new fees" scenario

Step 2 of Figure 5-2 shows all the inputs and the list of options to be selected to refer to economic scenarios specific to the context of interest in the Projections Inputs page. Some of the answers offered in this module are categorical while others require users to input specific numbers. Within this step, the user adjusts any irrelevant inputs that were set by default.

Working with economic scenarios is similar to working with project profiles. Refer to **Section 4.1.2** for information about selecting, creating, saving, and deleting scenarios within FUND (Step 3 of Figure 5-2).

Saving a new scenario is an essential function within FUND as it populates the database with commonly encountered cases in the user's context. These scenarios and the inputs associated with them are saved in the database, allowing them to persist between runs. This also allows multiple users to access the scenarios in cases where the Access database file is shared through file-share systems or e-mail.

Finally, click the "OK" button when completed, as shown in Step 4 of Figure 5-2**.**


1
Information about the selected Project Profile
3
Save or delete profile
Projection Inputs
Profile:
Good Economy, large increase in fees
Save
Delete
Memo:
This is if the economy is great, and a large increase additional revenues is developed. The user may select which revenues to project and which ones to leave alone.
Economic inflation:
Identify average economic inflation. A default of 2.5% will be used.
1
%
Highway Cost Index (HCI):
Identify the average Highway Cost Index (HCI). A default of 120 will be used.
100
Oil Barrel Price:
Identify how much one barrel of oil is selling for. In 2020 dollars, a low oil barrel price is $48, while a high oil barrel price is $173. A default of $100 will be used
$48
Fuel Economy
Average Fuel Economy of a Conventional Vehicle (mpg):
What is the average fuel economy of a conventional vehicle? A default of 24.1 miles-per-gallon will be used.
24.1
Average Fuel Economy of a Hybrid Vehicle (mpg):
What is the average fuel economy of a hybrid vehicle? A default of 108.1 miles-per-gallon will be used.
108.1
2
List of Projections Input
Vehicle-Miles-Travelled (VMT)
VMT Per Capita:
How many vehicle miles are travelled in a year per capita? A default of 9940 vehicle-miles per year will be used.
9940
VMT Fee Introduced:
How much is the proposed VMT fee? In cents/(vehicle*mile)
5
Electric Vehicles
Electric Vehicle Growth Rate/Year:
What is the growth rate of EV purchases and ownership in one year? A default of 10% per year will be used.
10
%
Electric Vehicle Fee Introduced:
How much is the proposed Electric Vehicle fee? In dollars per vehicle per year. A default value of $250/vehicle-year will be used. A range of $50 to $350 is generally appropriate.
$350
Motor Fuel Tax
Current Fuel Tax Amount:
How much is the current Texas motor vehicle fuel tax? A default value of 20 cents/gallon, for the value in 2020, will be used.
20

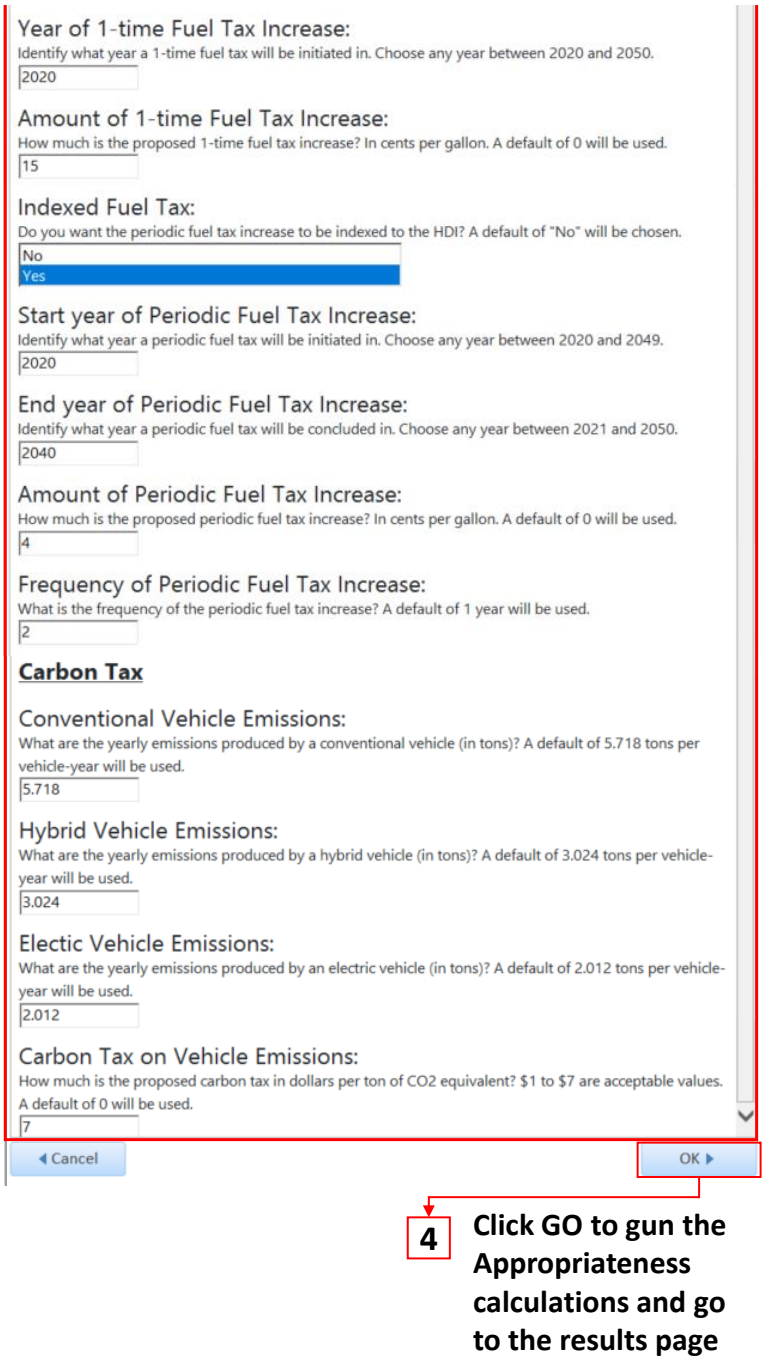


Figure 5-2 Projections Inputs Page User Interface

5.1.3. Results Page

Similar to the report for the Appropriateness Scores, the Projections will display after answering initial questions. Six separate pages are used in conjunction to display all the revenue and non-revenue projections, both in graphical and tabular formats. An example of the output for the revenue projections graph is shown in **Figure 5-3**.

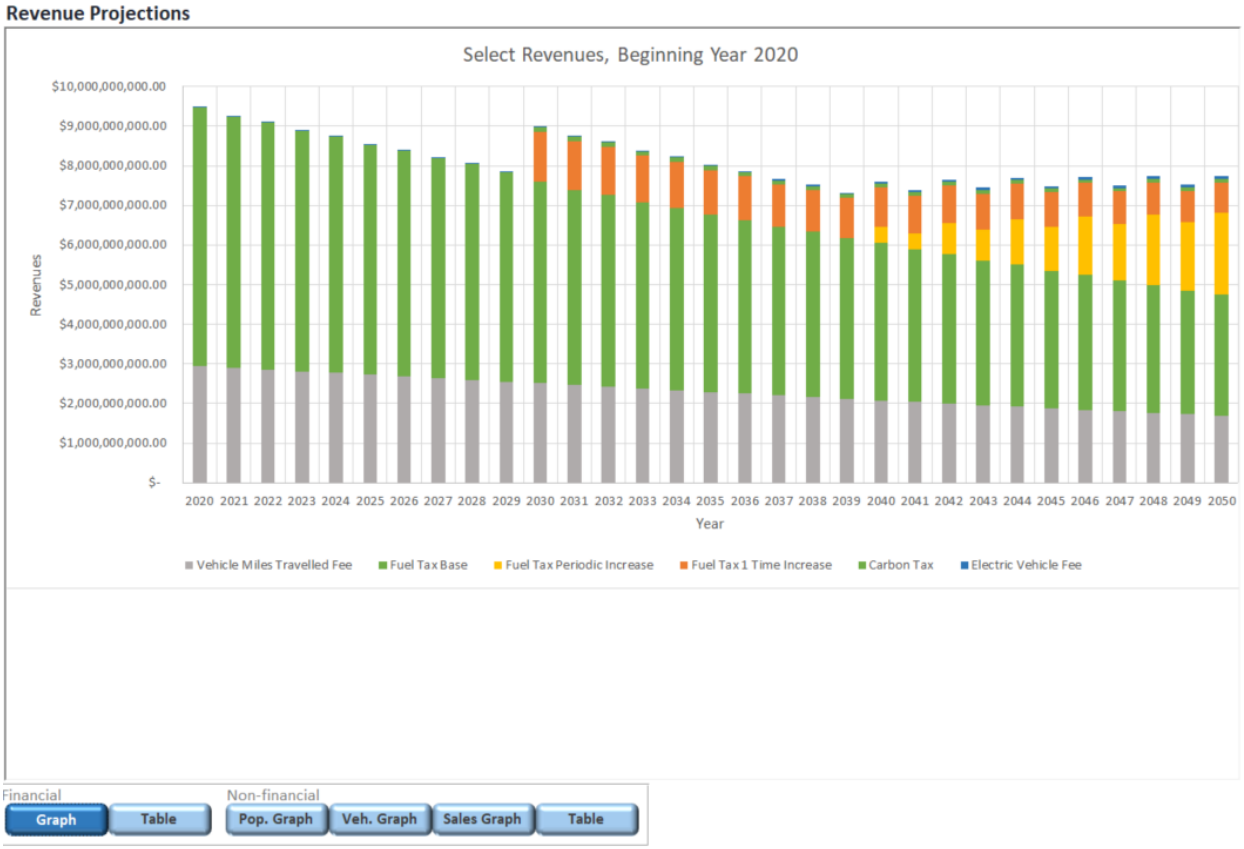


Figure 5-3 Revenue Projections Chart, as an example

The tabular version of this graph is shown in **Figure 5-4**. It is possible to double-click on each of these outputs to activate Microsoft Excel on them. At that point, contents can be temporarily altered in place, or copied and pasted to any other application. To close the activation and return to the FUND application, click anywhere to the left or right of the activation area, or press the ESC key.

Revenue Projections

Year	EV Fee	Total Gasoline Gallons	Total Diesel Gallons	1 Time Fuel Tax Change	Periodic Fuel Tax Change	Fuel Tax Base	VMT Fee	Carbon Tax
2020	$ 3,641,800.00	23867965871	8098749241	$ -	$ -	$6,393,343,022.42	$ 2,942,267,269.53	$ 135,378,819.01
2021	$ 4,892,505.14	23858139682	8298749241	$ -	$ -	$6,213,891,579.29	$ 2,900,741,323.22	$ 133,401,552.05
2022	$ 6,139,106.61	24245840622	8498749241	$ -	$ -	$6,113,485,003.31	$ 2,858,659,263.49	$ 131,437,364.29
2023	$ 7,509,232.00	24232829843	8698749241	$ -	$ -	$5,940,479,508.21	$ 2,816,106,188.90	$ 129,454,419.64
2024	$ 8,918,738.37	24619305837	8898749241	$ -	$ -	$5,841,809,717.13	$ 2,773,162,078.50	$ 127,460,267.01
2025	$ 10,362,054.89	24604969764	9098749241	$ -	$ -	$5,675,525,405.04	$ 2,729,902,040.73	$ 125,461,715.26
2026	$ 11,837,994.27	24988639394	9298749241	$ -	$ -	$5,578,562,549.25	$ 2,686,396,551.44	$ 123,470,421.77
2027	$ 13,337,458.75	24971149910	9498749241	$ -	$ -	$5,418,605,829.60	$ 2,642,711,681.26	$ 121,482,217.62
2028	$ 14,870,674.28	25352728201	9698749241	$ -	$ -	$5,323,699,406.36	$ 2,598,909,312.95	$ 119,494,784.10
2029	$ 16,518,245.52	25333035201	9898749241	$ -	$ -	$5,170,130,290.10	$ 2,555,047,349.10	$ 117,509,424.73
2030	$ 18,304,216.67	25711781066	10098749241	$ 1,269,337,933.16	$ -	$5,077,351,732.66	$ 2,511,179,910.56	$ 115,529,317.62
2031	$ 20,259,672.77	25688719415	10298749241	$ 1,232,473,120.18	$ -	$4,929,892,480.72	$ 2,467,357,525.98	$ 113,556,390.43
2032	$ 22,404,638.00	26063619967	10498749241	$ 1,209,818,264.38	$ -	$4,839,273,057.51	$ 2,423,627,312.85	$ 111,592,029.36
2033	$ 24,719,955.50	26036384452	10698749241	$ 1,174,429,852.10	$ -	$4,697,719,408.39	$ 2,380,033,150.48	$ 109,637,754.48
2034	$ 27,235,723.12	26406713396	10898749241	$ 1,152,331,774.74	$ -	$4,609,327,098.96	$ 2,336,615,845.08	$ 107,694,954.93
2035	$ 29,964,303.55	26374527698	11098749241	$ 1,118,372,372.71	$ -	$4,473,489,490.85	$ 2,293,413,287.43	$ 105,764,313.63
2036	$ 32,866,748.54	26739921882	11298749241	$ 1,096,856,325.52	$ -	$4,387,425,302.10	$ 2,250,460,603.43	$ 103,846,793.77
2037	$ 35,899,251.01	26702941979	11498749241	$ 1,064,306,336.43	$ -	$4,257,225,345.73	$ 2,207,790,297.71	$ 101,943,682.85
2038	$ 39,050,996.92	27063502903	11698749241	$ 1,043,404,511.80	$ -	$4,173,618,047.19	$ 2,165,432,390.80	$ 100,056,132.33
2039	$ 42,292,130.42	27021622453	11898749241	$ 1,012,232,640.42	$ -	$4,048,930,561.68	$ 2,123,414,549.93	$ 98,184,781.64
2040	$ 45,577,218.03	27377441000	12098749241	$ 991,969,323.13	$ 410,675,299.78	$3,967,877,292.53	$ 2,081,762,213.87	$ 96,330,606.81
2041	$ 48,869,742.28	27331046430	12298749241	$ 962,153,783.15	$ 398,331,666.22	$3,848,615,132.61	$ 2,040,498,712.01	$ 94,494,576.57
2042	$ 52,083,195.07	27682845706	12498749241	$ 942,561,030.72	$ 794,098,242.77	$3,770,244,122.86	$ 1,999,645,377.95	$ 92,677,594.07
2043	$ 55,291,442.49	27632711707	12698749241	$ 914,083,591.46	$ 770,106,284.97	$3,656,334,365.85	$ 1,959,221,657.78	$ 90,879,838.32
2044	$ 58,424,527.92	27980833180	12898749241	$ 895,175,237.59	$ 1,151,174,900.78	$3,580,700,950.34	$ 1,919,245,213.32	$ 89,102,211.35
2045	$ 61,476,158.12	27926996764	13098749241	$ 867,996,045.23	$ 1,116,223,080.45	$3,471,984,180.91	$ 1,879,732,020.64	$ 87,345,744.80
2046	$ 64,498,991.35	28270929939	13298749241	$ 849,762,540.58	$ 1,482,824,034.27	$3,399,050,162.33	$ 1,840,696,463.76	$ 85,610,674.72
2047	$ 67,450,476.06	28212892431	13498749241	$ 823,830,455.38	$ 1,437,572,899.55	$3,295,321,821.50	$ 1,802,151,424.16	$ 83,897,239.89
2048	$ 70,339,216.80	28552781088	13698749241	$ 806,273,996.92	$ 1,789,977,353.09	$3,225,095,987.70	$ 1,764,108,365.90	$ 82,205,874.77
2049	$ 73,168,016.66	28490620708	13898749241	$ 781,550,097.95	$ 1,735,088,792.37	$3,126,200,391.81	$ 1,726,577,416.73	$ 80,536,593.06
2050	$ 75,904,812.49	28826543697	14098749241	$ 764,667,757.13	$ 2,073,597,733.40	$3,058,671,028.51	$ 1,689,567,445.44	$ 78,889,714.14

Financial: Graph | Table

Non-financial: Pop. Graph | Veh. Graph | Sales Graph | Table

Figure 5-4 Revenue Projections Table, as an example

5.2. Calculations

To understand the financial landscape of future projects, it is beneficial to leverage models that can be configured according to hypothetical future scenarios. This project uses different methods to forecast both revenue and non-revenue data sources. The revenue projections are directly related to changes within the economic environment and funding availability over time. The non-revenue projections include population, employment, or vehicle ownership models. The next two sections address the revenue and non-revenue projections, analyzing inputs, reasoning, calculations, and outputs.

Figure 5-5 depicts the general framework used for achieving the revenue projections for a subset of the funding mechanisms (*1*).

Three types of inputs were considered in this module: non-revenue projections, assumptions, and policy testing variables. The predictions generated for the inputs required for revenue projection are referred to as non-revenue projections in this context. This corresponds to all the inputs that need to be estimated for every year within the analysis period, such as population or EV ownership (*1*).

The general assumptions include variables that affect the non-revenue and revenue projections but are assumed to remain constant during the analysis period. The third input type corresponds to policy testing variables which are used to experiment with different tax rates and fees to evaluate their effects on the net revenues. Only a few mechanisms were considered for the Projections module for simplicity (*1*).

The non-revenue projections and general assumptions were obtained from TxDOT publications to reflect their specific trends. Since the inputs are not generalizable for other locations, the details concerning their collection and their specific numerical values are excluded from this study for brevity (*1*).

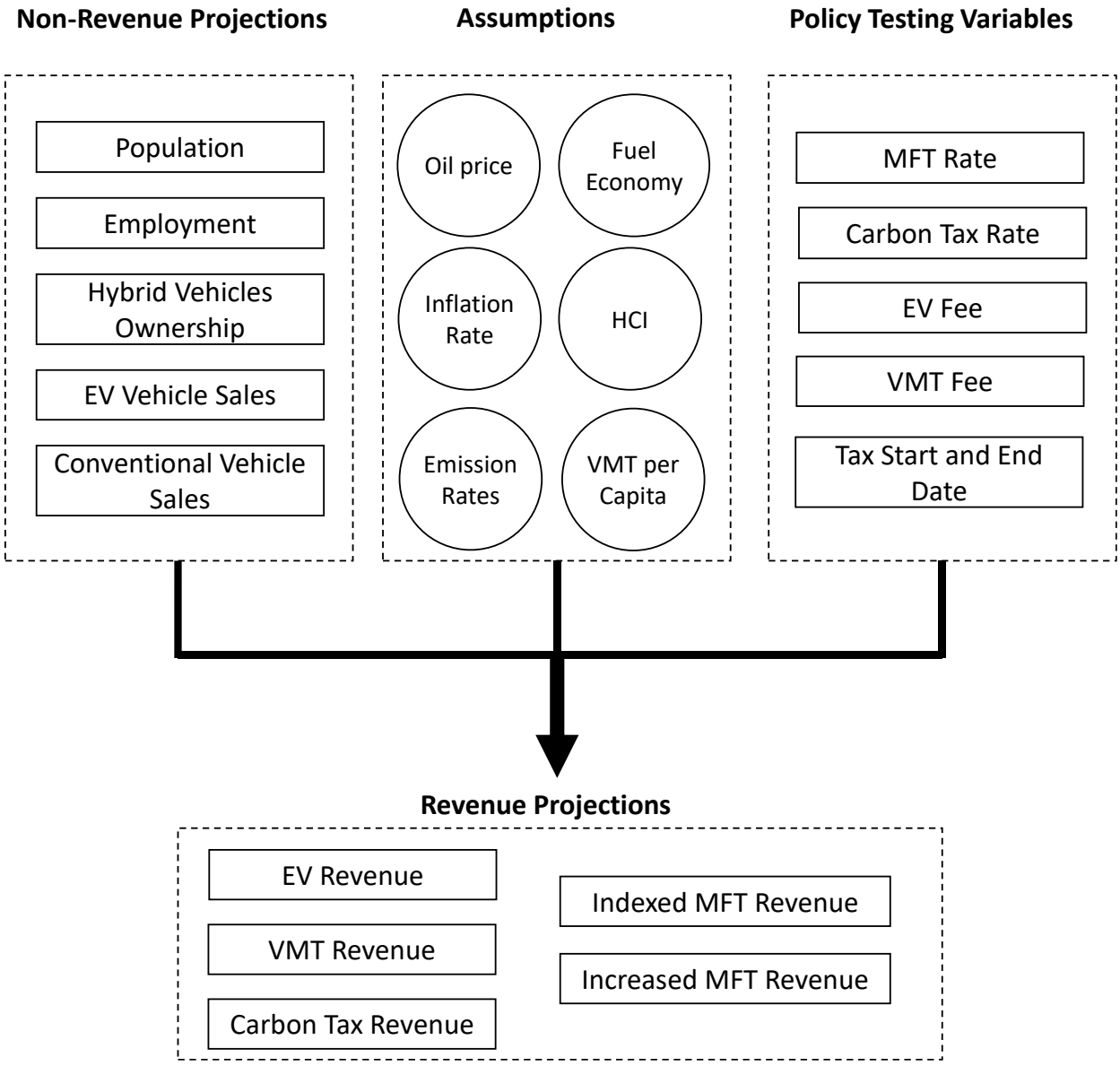


Figure 5-5 Framework for Financing Mechanisms Revenue Projections (*1*)

5.3. Non-Revenue Projections

The non-revenue projections are specific to the state of Texas, not taking into consideration national numbers or growth. The completed projections consist of population, employment, registered vehicle count, and vehicle sales count. These non-revenue-based projections assist in determining future revenue projections. Many different sources and calculations were compiled to develop these projections and

align them with past growth. The final outputs for each of the non-revenue projections are provided in a single graph and numeric table.

5.3.1. Population

Using information from the Data Commons source (Place Explorer - Data Commons, Demographics, 2019), the Texas state population counts were extracted from years 1900 to 2019. A projected population was calculated from these. The resulting function that describes and projects the population of Texas is:

$$Population = 1.33253 * 10^{-9} * e^{0.01864 * year}$$

All projection calculations in FUND use this model, whose results are shown in **Figure 5-6**.

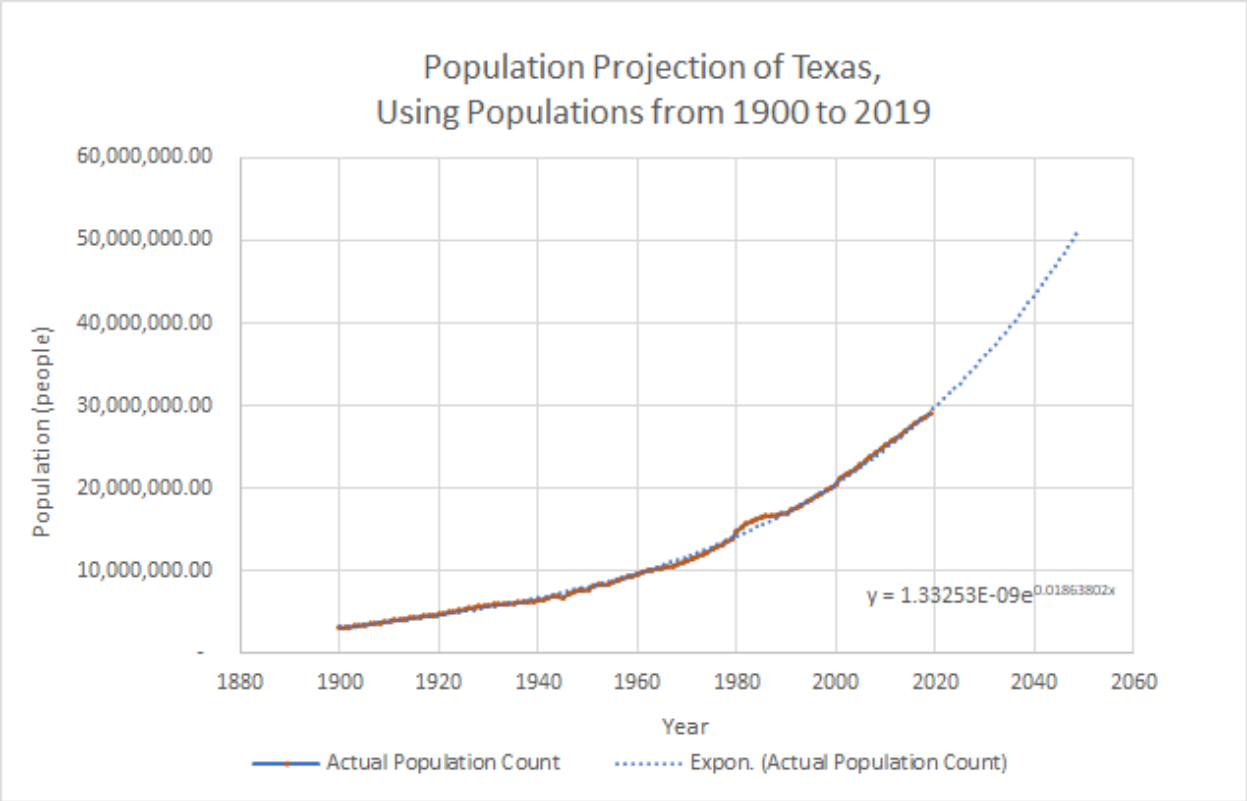


Figure 5-6 Population Projection

Exhibit 5-1 Excel Implementation of Population Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

The population data are spread out over 3 sheets. First, in the INPUT TABLE sheet, the inputs that the user specifies in the FUND database are integrated. The based on the selected base year, the starting year in cell B7 of the "Population" sheet is determined. The data shown in that sheet are specific to the state of Texas. To tailor this input to the users' context, the values in column C should be updated to reflect the proper population values. Finally, the data from cells B7:C38 of the "Population" sheet is plotted in the "Non-Revenue - Pop. Graph" sheet, and the growth function is obtained via regression, as presented in **Figure 5-6**.

5.3.2. Employment

Total employment was calculated from other sources, broken down by the month of the year, using the number of employed persons within Texas (Place Explorer - Data Commons, Economics, 2019). To find the average yearly employed population, an average of all months was taken for each year. This also helped in smoothing out any extreme growth or decline that appeared in the month-to-month figures. Again, the Data Commons source helped determine these trends. A regression analysis produced this model:

$$Employment = 172661 * year - 335{,}500{,}000$$

Figure 5-7 shows significantly steady employment growth apart from isolated cases, such as year 2020. When taking the year 2020 into account, the data showed a sharp decline, which can be attributed to the COVID-19 pandemic. The output aligns with the past data provided.

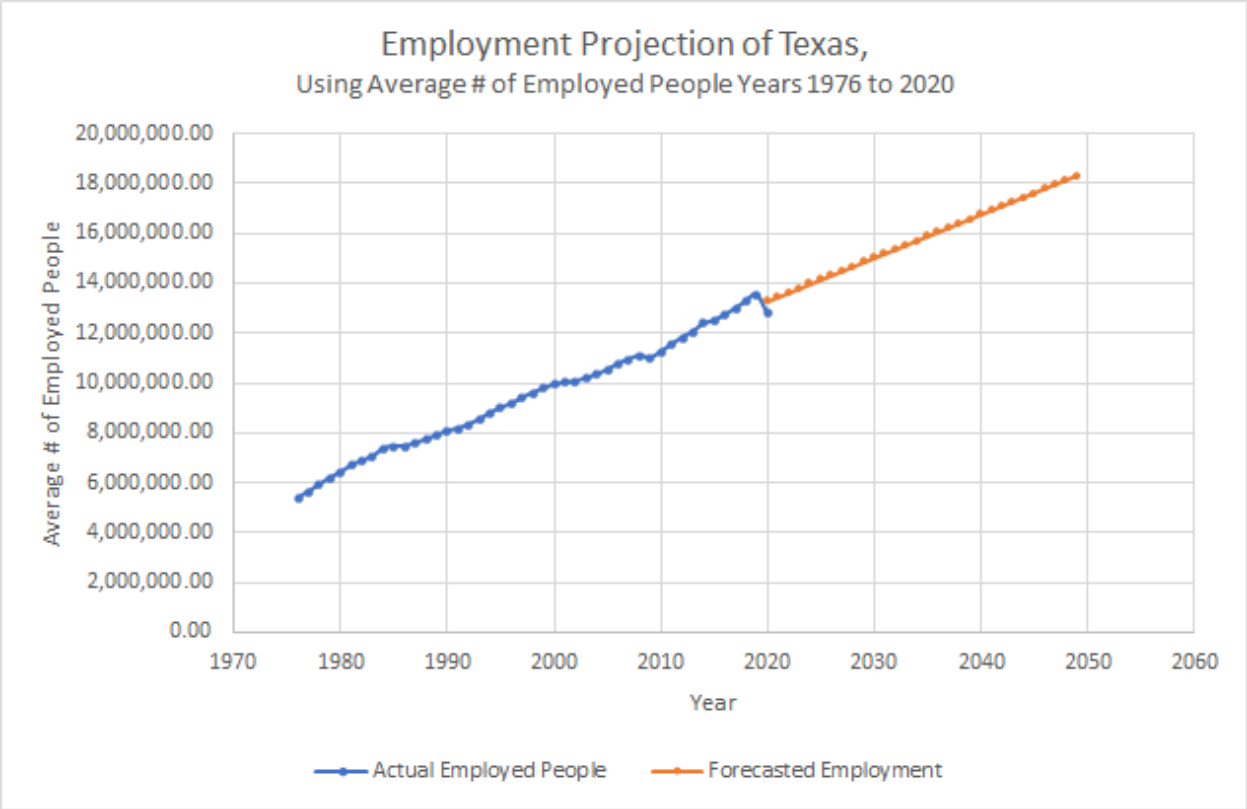


Figure 5-7 Employment Projection

Exhibit 5-2 Excel Implementation of Employment Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

The employment data are spread out over 2 sheets. First, in the "INPUT TABLE" sheet, the inputs that the user specifies in the FUND database are integrated. The based on the selected base year, the starting year in cell B7 of the "Employment" sheet is determined. The data shown in that sheet are specific to the state of Texas. To tailor this input to the users' context, the values in column C should be updated to reflect the proper population values. Finally, the data from cells B7:C38 of the "Employment" sheet is plotted as presented in **Figure 5-7**.

5.3.3. Registered Vehicle Count

The total registered vehicle count was obtained for automobiles, buses, trucks, and motorcycles. The main source for this count was the Texas Department of Motor Vehicles (DMV) Alternatively Fueled Vehicle Report (Alternatively Fueled Vehicle Report, 2020). This report provided the number of registered vehicles, according to fuel type, for years 2016 to 2020. These numbers were then used to project into the future, as the growth rates appear consistent over that period. As **Figure 5-8** demonstrates, hybrid vehicle market penetration is expected to continue growing at an increasing rate, even if the graph shows a dip in growth for 2019 and 2020.

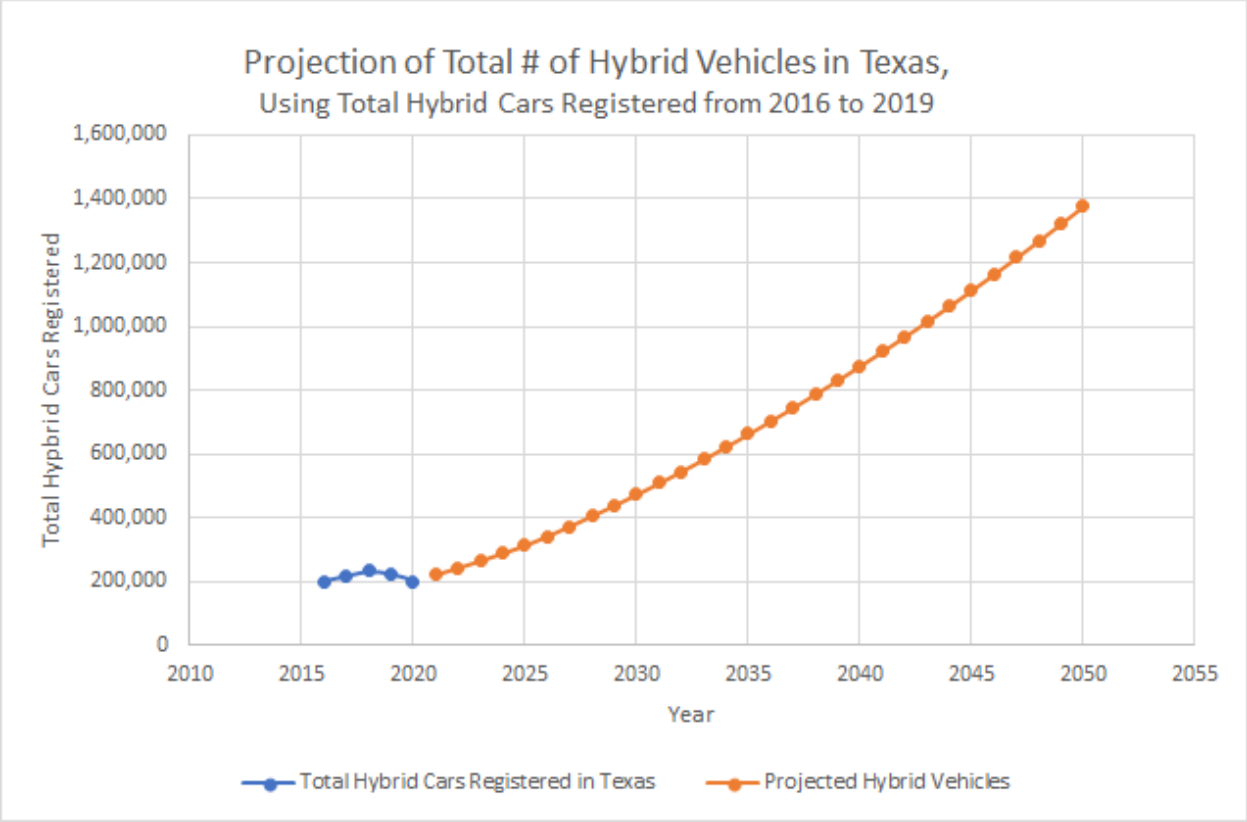


Figure 5-8 Hybrid Vehicle Projection

Exhibit 5-3 Excel Implementation of Hybrid Vehicle Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

The hybrid vehicle projections data is provided in the "Hybrid Vehicle Projection" sheet. Column D includes all the registered hybrid vehicles each year. Column E includes the difference of the number of registered hybrid vehicles in two consecutive years to obtain the new hybrid car sales.

To tailor this input to the users' context, the values in column D should be updated to reflect the proper values. Finally, the data from cells E7:E38 of the "Hybrid Vehicle Projection" sheet is plotted as presented in **Figure 5-8**.

Another source for the number of registered vehicles in Texas was the USDOT Highway Statistics report (Highway Statistics, 2020). Different vehicle types all had independent growth rates, although the truck growth rate was much higher than that of the other vehicles. Overall, the number of vehicles on the road—of all types—is projected to grow (see **Figure 5-9**).

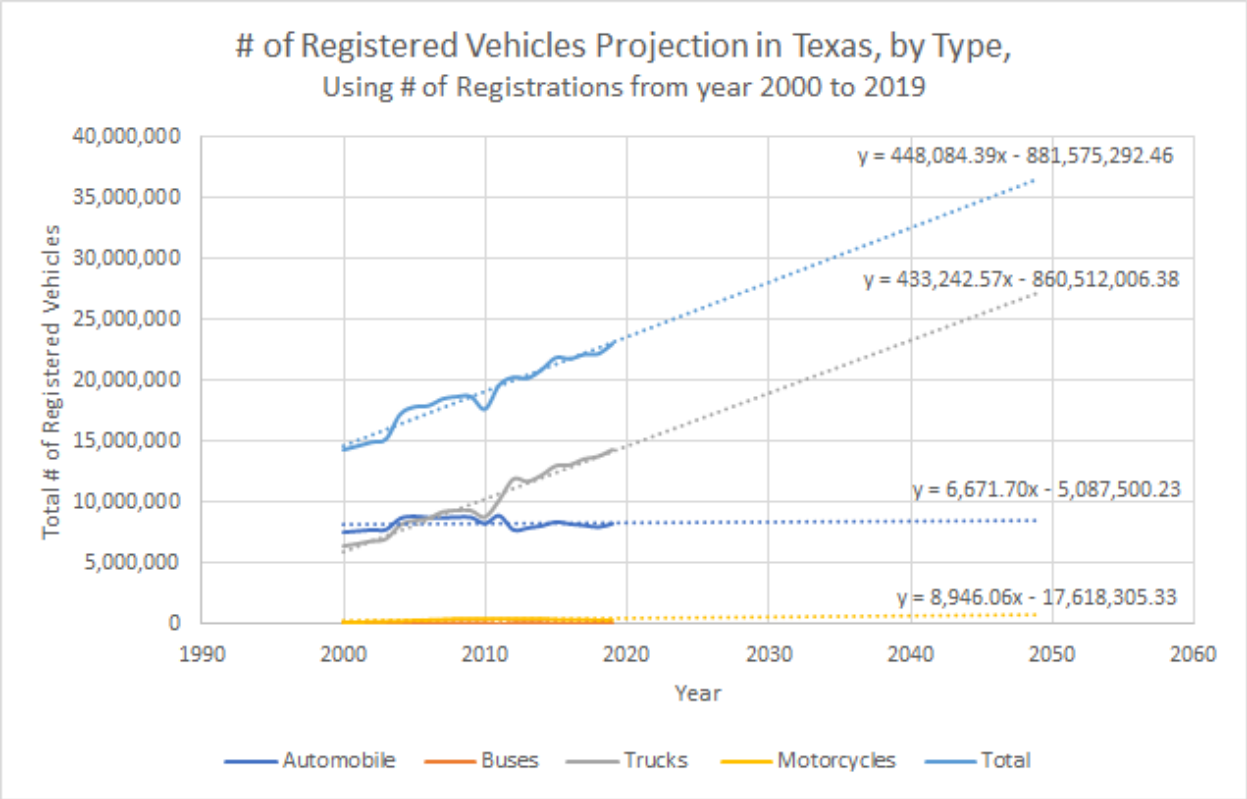


Figure 5-9 Registered Vehicle Projection

Exhibit 5-4 Excel Implementation of Registered Vehicles Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

The registered vehicle projections data is provided in the "Registered Vehicles" sheet. Columns D, E, F, and G include the number of registered automobiles, trucks, busses, and motorcycles for each year. Column H sums over all the vehicle types each year.

To tailor this input to the users' context, the values in columns D through G should be updated to reflect the proper values. Finally, the data from cells C8:H39 of the "Registered Vehicles" sheet is plotted as presented in **Figure 5-9**.

5.3.4. Vehicle Sales

Vehicle sales were projected for electric vehicles (EV) and conventional vehicles. The EV projection consists of two methods: based on EV growth rate (as an input from the user), or based on the oil price at the current year (as an input from the user). Conventional vehicle sales were projected using only the oil price at the current year.

In the first EV method, a user-input growth rate (i.e., 10 percent per year) was used to project growth in sales. Data from the DMV's Alternatively Fueled Vehicle Report were also used here to base the projections of EVs on EV growth rates from 2016 to 2020 (Alternatively Fueled Vehicle Report, 2020). Another report used to develop the projection was a DMV study on imposing fees for alternatively fueled vehicles (Study on Imposing Fees on Alternatively Fueled Vehicles, 2020). That report projects sales into 2028, which the research team extrapolated further into 2050, as **Figure 5-10** depicts.

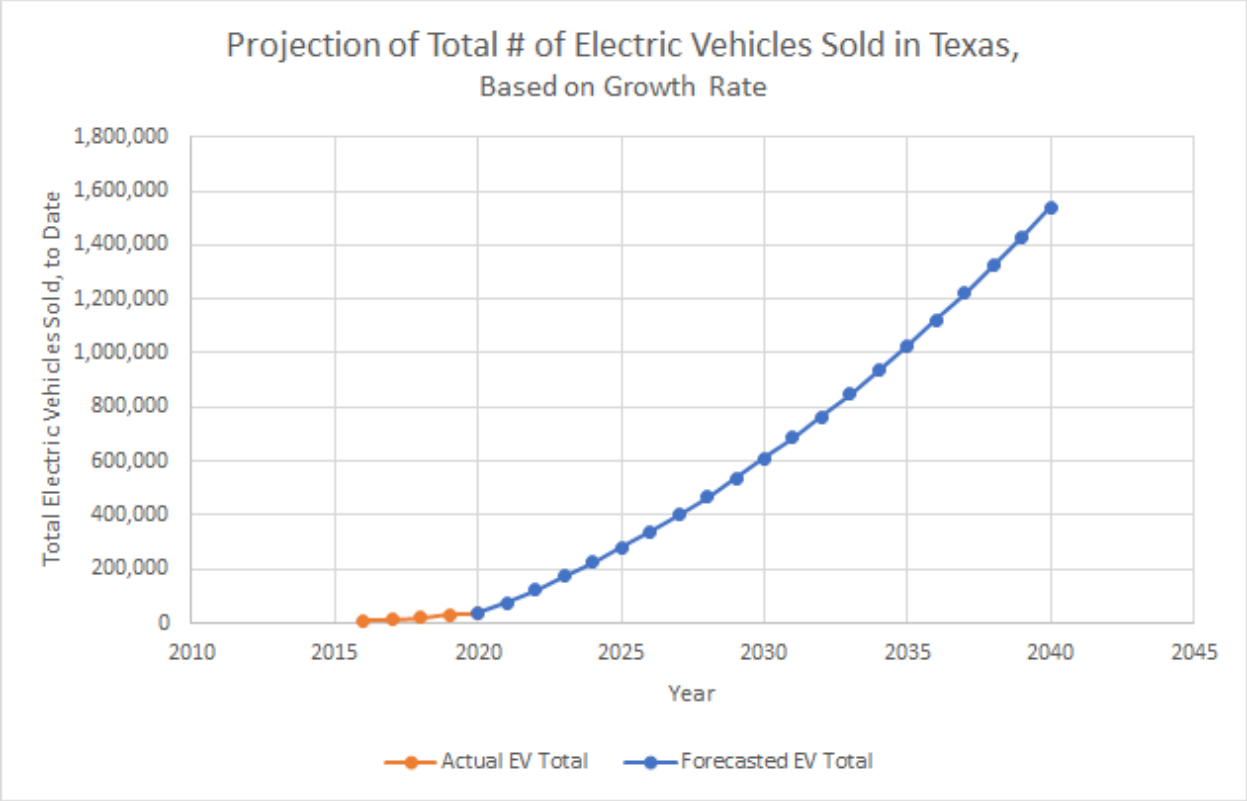


Figure 5-10 EV Sales, based on growth rate

The second method to project both EV and conventional vehicles was based on the oil barrel price. A report from the US Energy Information Administration shows that the barrel price may affect the number of hybrid and electric vehicles sold. After data extraction from their report was completed (Annual Energy Outlook, 2020), the research team was able to estimate EV sales with high barrel prices and with low barrel prices per year, which also helped to determine the number of conventional vehicle sales per year. General trends showed that higher oil prices induced more EV sales in a certain year. More importantly, as the EV sales increased, the conventional vehicle sales decreased.

In FUND, these trends are configurable according to the user inputs. The user provides the oil barrel price, and then is able to see the trends in sales per year. The base year is set at 2020. Each of these projections is based on the previous sales data and is projected out into the future, as shown in **Figure 5-11**.

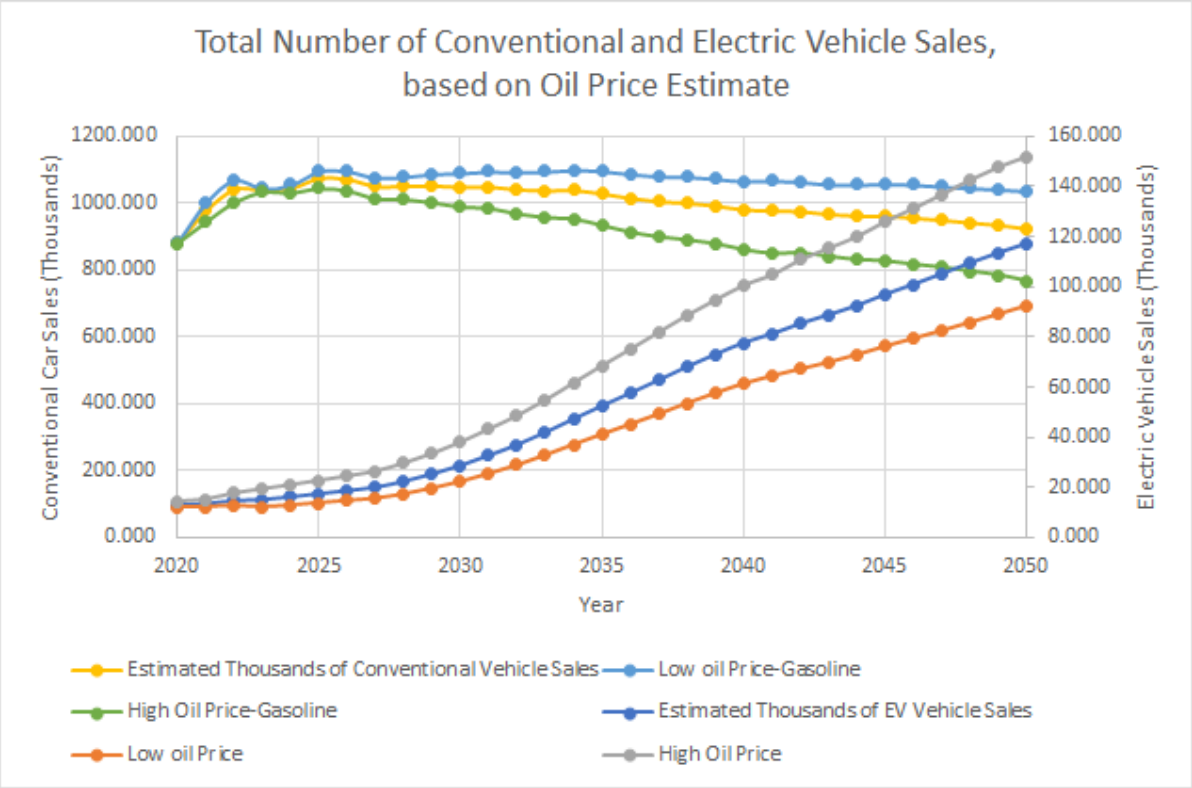


Figure 5-11 EV and conventional vehicle sales, based on oil barrel price

Exhibit 5-5 Excel Implementation of EV Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

The EV projections data is provided in the "EV" sheet. To tailor this input to the users' context, the values in columns C and D should be updated to reflect the proper values. Finally, the data from cells B9:D49 of the "EV" sheet is plotted as presented in **Figure 5-10**.

Another set of EV projections is also provided in cells B55:I86 which relates the number of vehicles to oil price scenarios. To tailor this input to the users' context, the values in columns C and D should be updated to reflect the proper values. Finally, the data from cells B55:I86 of the "EV" sheet is plotted as presented in **Figure 5-11**.

5.4. Revenue Projections

The revenue projections are based on four hypothetically projected sources: Electric Vehicle Fee (EV Fee), Motor Fuel Tax, Vehicle-Miles-Traveled Fee (VMT Fee), and Carbon Tax. Each of these four revenue projections can be adjusted for different inputs or scenarios, depending on what the user chooses to include. All revenue projections are expressed in terms of 2020 value per dollar, using a present value to future value estimation. (The base year can be reconfigured in future work.) These revenue projections were inspired by the Indiana DOT work on revenue projections in their 2015 report (Cambridge Systematics and D'Artagnan Consulting, 2015).

The final outputs, both in table and graph form, are shown at the end of this section (**Figure 5-12** and **Table 5-2**). All revenue projections also account for inflation, which is why the revenues appear to decrease over time. The non-revenue projections described in the previous section assist in projecting the revenues of different sources, and may be useful in future work conducted by TxDOT or other entities.

5.4.1. EV Fee

To estimate the EV Fee revenue from EV growth rates based on oil barrel price, the total projected number of EVs was calculated by adding the growth each year to the existing total. Then, a simple fee was modeled that would charge each EV once per year (or it can be adjusted to charge only newly registered EVs one time). From this point, the user-inputted EV fee is multiplied by the number of EVs in Texas, and a yearly present value of the fee is produced. A simple calculation converts the value into 2020 dollars; this calculation changes according to the present inflation. The only required inputs by a user are the EV fee, the price of an oil barrel, and the inflation rate (if included at all). The outputs of this projection include the amount of funding raised by increasing or changing an EV fee in the current year.

Some states have already introduced an EV fee to increase revenue, especially because EV users do not contribute much (if any) to motor fuel revenues. Generally, a fee of anywhere from $50 to $300 is considered adequate, though a fee outside of this range could still be beneficial for the state.

Exhibit 5-6 Excel Implementation of EV Fee Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

In the "Revenues – Table" sheet, column D provides the final EV revenues based on the EV fee that is inputted by the user in "INPUT TABLE" sheet cell B13 multiplied by the total EV count (product presented in column C), then modified based on the inflation rate inputted by the user in "INPUT TABLE" sheet cell B2 (note that the inputs presented in INPUT TABLE are either provided by default or modified by the user through the FUND interface).

To modify the EV fee revenue projection values the user should change the total EV count values in cells AC50:AC80 in the "EV" sheet or the EV fee "INPUT TABLE" sheet cell B13.

5.4.2. Motor Fuel Tax

The Motor Fuel Tax is a major revenue source for DOTs around the country, and that is no different for Texas. This revenue source was coded to handle three types of plausible changes: a one-time change, a periodic change, or a combination of the two.

The general inputs required for the Motor Fuel tax projection include:

- current Motor Fuel tax amount,
- average fuel economy of hybrid and conventional vehicles,
- oil price, and
- inflation rate.

Additional inputs are required for the specific type of change projected. Calculating the one-time change requires two additional inputs: the year of increase and the associated amount of increase. For example, the user could choose a 5-cent tax increase per gallon of fuel for the year 2040, and future revenue would be projected accordingly (in 2020 dollars). The periodic change requires similar, but more specific, inputs: amount of the increase, period, and a start year and end year for the increase. For example, the user could select a 3-cent increase per gallon to occur every 5 years. This means that the current gas tax, at 20 cents per gallon, would increase to 23 cents per gallon in 5 years, and 26 cents per gallon in 10 years (not considering inflation). Additionally, the user has the ability to limit the years of increase. For example, the user could select a 3-cent increase every year from 2030 to 2040, but then not increase the tax further after 2040.

Finally, a combination of changes can be calculated. The user could input a 10-cent-per-gallon increase in 2022, and then a 5-cent-per-gallon increase every 2 years after that. Another question included in the projection is whether the calculations are held constant or indexed to the inflation rate. This calculation is possible with the current coding in the projection model.

Exhibit 5-7 Excel Implementation of MFT Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

In the "Revenues – Table" sheet, columns G through I provide different MFT revenue projections. These projections are based upon the inputs given by the user in the "INPUT TABLE" sheet cells B15 through B22. For the 1-time fuel tax increase, cell B17 is multiplied by the projected number of gallons of gas sold in any certain year. The excel sheet is coded to account for a specific year of a 1-time increase (inputted in cell B16). For the periodic fuel tax increase, the revenue projection depends on cells B18 through B21 in the "Revenue Projections – Table". The projection for a periodic increase multiplies the amount of fee increase (cell B18) by the projected number of gallons of gas sold in any certain year. Cell B19 accounts for the start year of this periodic increase, and cells B20 and B21 allow for a time window for this periodic increase to occur. All these calculations were completed within the "GasTax Calcs" sheet in the cells G11:J41. Additionally, the fuel tax base (column I in the "Revenues – Table"), was calculated using input cell B15 multiplied by the projected number of gallons of gas sold in any certain year. All these revenues can be indexed to the inflation rates depending on the input of cell B22.

To modify the MFT fee revenue projection values the user should change the projected number of gallons of gasoline sold in cells K48:K78 in the "Gas Tax" sheet or the various MFT fees in the "INPUT TABLE" sheet cells B15:B22.

5.4.3. VMT Fee

The third revenue projection is the VMT Fee. Because the total number of vehicles was already projected, the VMT is straightforward to estimate. The VMT for an individual vehicle is based on the calculation of the miles traveled for that vehicle in a given year, multiplied by a chosen mileage fee.

For this projection, the inputs required are the amount of the fee to be introduced (in cents per vehicle-mile), and the average VMT per capita in Texas. The inputted value of average VMT per capita is then multiplied by the number of chargeable travelers in Texas, giving an annual number for the total VMT for Texas. Then, the fee is multiplied by the total VMT to find the estimated revenue gain. VMT can be a powerful tool for gaining revenue, but tracking it presents some challenges, including privacy concerns, technological complexities, and legislative buy-in.

Exhibit 5-8 Excel Implementation of VMT Fee Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

In the "Revenues – Table" sheet, column J provides the VMT revenue projections. The final VMT revenue projections are based on the VMT fee that is inputted by the user in the "INPUT TABLE" sheet cell B7 multiplied by cell B8 and the projected population.
To modify the VMT fee revenue projection values the user should change the VMT fee value or the VMT per person ("INPUT TABLE" sheet cell B7 and B8).

5.4.4. Carbon Tax

The final revenue projection was for a Carbon Tax, which is a tax placed on items that produce emissions and pollution to encourage the use of more sustainable methods. Texas could potentially propose the addition of a carbon tax to its tax structure, though the state has not enacted any specific carbon tax as of this time.

This model uses the non-revenue projections to supply the total number of conventional, hybrid, and electric vehicles, so only two types of input are required from the user to project revenues from a carbon tax: vehicle emission values for those three vehicle types, and the amount of carbon tax to be assessed per ton of CO_2 equivalent. (An emissions estimate is required for EVs because their development and manufacturing create emissions, which should be considered when assessing this tax.) The emission values that are inputed by the user are in tons of CO_2 equivalent per year, with a suggested value of 5.718 for conventional vehicles, 3.024 for hybrid vehicles, and 2.012 for EVs.

Exhibit 5-9 Excel Implementation of Carbon Tax Projections

Refer to the `projections.xlsx` Excel workbook for the implementation of the Projection's module calculations.

In the "Revenues – Table" sheet, column K provides the Carbon tax projections. These projections are based on the estimated amount of emissions produced by different types of cars (inputted in the "INPUT TABLE" sheet cells B25:B27). Projections for the number of conventional, hybrid, and electric vehicles within the state were projected in the "Registered Vehicles" sheet cells D9:H39. These numbers were multiplied with the emissions estimates as inputted by the user, and then multiplied by the carbon tax inputted by the user ("INPUT TABLE" sheet cell B24).

To modify the Carbon Tax revenue projection values the user should adjust the emissions estimates or modify the number of registered vehicles in the "Registered Vehicles" sheet cells D9:H39.

5.4.5. Revenue Projection Graph

For an example revenue projection, these values were considered:

Table 5-1 Example of an input table

Variable or Input	Value	Unit
Inflation Rate	2.5	%
Highway Cost Index	1.2	
Oil Price	100	$/barrel
VMT Fee	1	cents/mile/vehicle
Avg VMT per Capita	9940	miles
EV Growth Rate	10	% per year
Average Fuel Economy of Conventional Vehicle	24.1	mpg
Average Fuel Economy of Hybrid Vehicle	108.1	mpg
EV Fee Induced	250	$/vehicle
Current Fuel Tax	20	cents
Year of Increase (For 1 Time Increase)	2025	
Fuel Tax 1 Time Increase	10	cents
Fuel Tax Indexed Periodic Increase	2	cents
Length of Year Intervals	3	years
Tax Increase Year Start	2030	
Tax Increase Year End	2040	
Carbon Tax	5	dollars per ton CO_2 equivalent
Conventional Vehicle Emissions	5.7175	tons CO_2 equivalent per year
Hybrid Vehicle Emissions	3.0235	tons CO_2 equivalent per year
Electric Vehicle Emissions	2.0115	tons CO_2 equivalent per year

Figure 5-12 shows the periodic increase of the fuel tax starting in 2030 and continuing until 2040, as well as a hypothetical one-time increase in 2025. This graph also shows how the value of money, with respect to the inflation rate, decreases over time. This hints at the idea that states may need to increase their taxes over time to account for inflation.

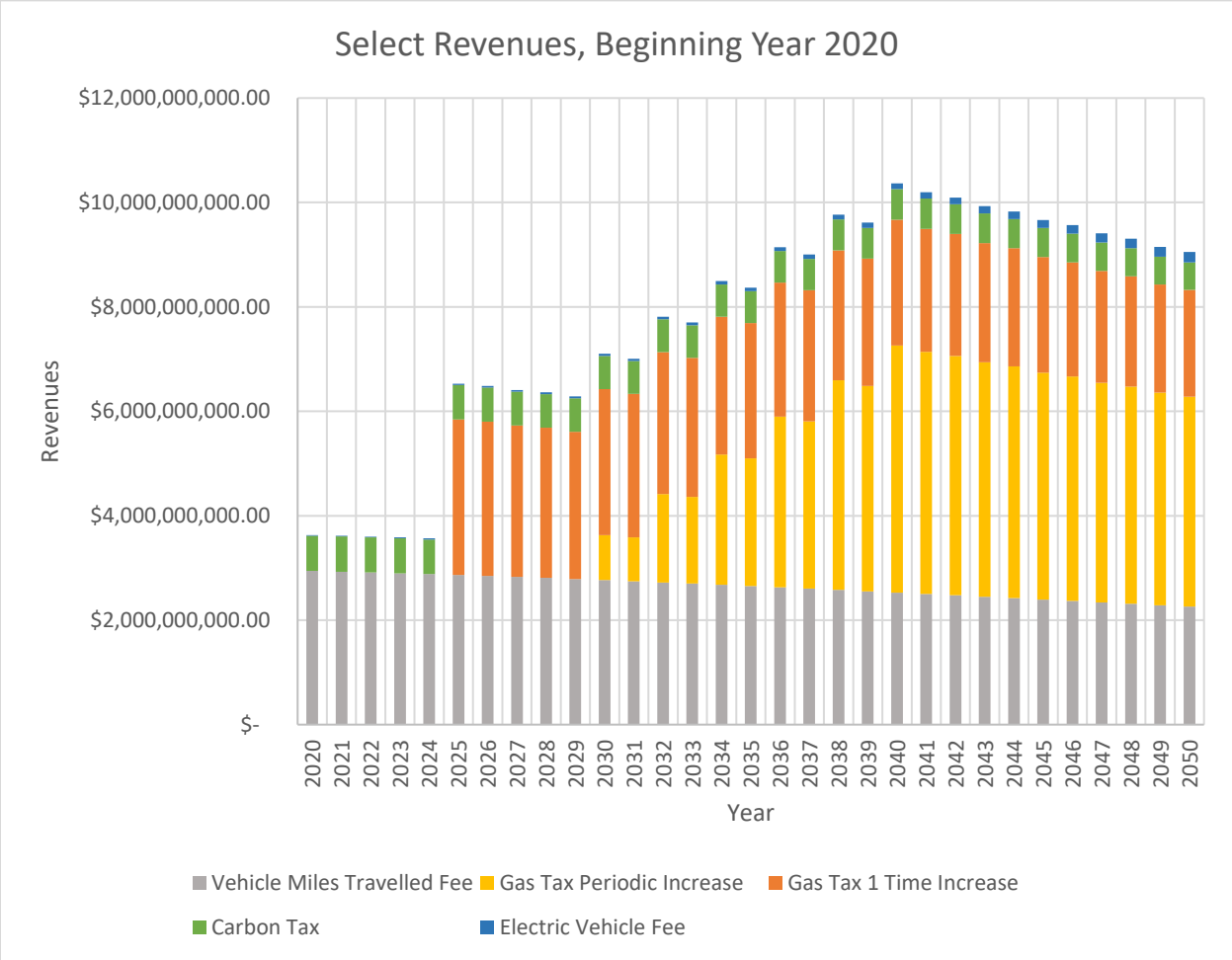


Figure 5-12 Revenue projections from 2020 onward using Table 5-1 inputs

5.4.6. Revenue Projection Table

The final revenue projection table with values for each of the projections is shown in **Table 5-2**, which summarizes the graph in **Figure 5-12**.

Table 5-2 Final revenue projection table

Year	EV Fee	1 Time Gas Tax Change	Periodic Gas Tax Change	Gas Tax Base	VMT Fee	Carbon Tax
2020	$9,104,500.00	$-	$-	$6,393,343,022.42	$2,942,267,269.53	$676,834,602.88
2021	$12,044,099.72	$-	$-	$6,274,514,911.77	$2,929,041,238.57	$673,455,886.52
2022	$14,958,306.68	$-	$-	$6,233,354,405.88	$2,914,710,072.13	$670,013,472.95
2023	$18,003,649.05	$-	$-	$6,116,048,987.63	$2,899,335,547.22	$666,343,248.55
2024	$20,987,372.90	$-	$-	$6,073,140,722.14	$2,882,977,084.76	$662,479,386.52
2025	$24,053,658.46	$2,978,917,655.06	$-	$5,957,835,310.12	$2,865,691,827.75	$658,453,620.86
2026	$27,231,608.89	$2,956,590,776.20	$-	$5,913,181,552.40	$2,847,534,717.08	$654,324,708.84
2027	$30,503,054.97	$2,899,832,781.22	$-	$5,799,665,562.44	$2,828,558,564.92	$650,069,090.23
2028	$33,876,563.17	$2,876,837,991.23	$-	$5,753,675,982.46	$2,808,814,125.88	$645,672,321.23
2029	$37,539,912.90	$2,821,108,903.83	$-	$5,642,217,807.66	$2,788,350,165.98	$641,139,206.10
2030	$41,575,680.35	$2,797,512,904.05	$860,235,217.99	$5,595,025,808.10	$2,767,213,529.45	$636,485,121.58
2031	$46,044,078.59	$2,742,766,145.94	$843,400,589.88	$5,485,532,291.88	$2,745,449,203.46	$631,719,144.88
2032	$51,019,182.49	$2,718,616,479.56	$1,692,848,499.12	$5,437,232,959.12	$2,723,100,380.87	$626,847,712.40
2033	$56,492,114.31	$2,664,841,448.32	$1,659,363,459.35	$5,329,682,896.64	$2,700,208,520.95	$621,878,311.77
2034	$62,540,610.44	$2,640,209,045.84	$2,496,990,081.08	$5,280,418,091.68	$2,676,813,408.28	$616,818,009.61
2035	$69,185,431.05	$2,587,400,702.85	$2,447,046,343.16	$5,174,801,405.71	$2,652,953,209.78	$611,670,096.43
2036	$76,349,891.60	$2,562,379,730.58	$3,271,898,974.54	$5,124,759,461.16	$2,628,664,529.95	$606,439,655.38
2037	$83,952,747.96	$2,510,596,264.18	$3,205,776,741.13	$5,021,192,528.35	$2,603,982,464.35	$601,133,905.81
2038	$91,971,644.78	$2,485,303,464.42	$4,017,048,227.03	$4,970,606,928.84	$2,578,940,651.48	$595,759,561.18
2039	$100,377,509.24	$2,434,577,122.81	$3,935,058,174.89	$4,869,154,245.62	$2,553,571,322.97	$590,320,536.78
2040	$109,067,848.31	$2,409,117,183.91	$4,732,057,943.07	$4,818,234,367.81	$2,527,905,352.15	$584,822,957.74
2041	$117,961,151.59	$2,359,503,684.82	$4,634,605,667.20	$4,719,007,369.65	$2,501,972,301.19	$579,273,155.18
2042	$126,868,019.03	$2,334,006,884.86	$4,584,524,112.18	$4,668,013,769.72	$2,475,800,466.67	$573,677,308.99
2043	$135,850,792.16	$2,285,572,752.56	$4,489,388,382.79	$4,571,145,505.12	$2,449,416,923.72	$568,037,318.53
2044	$144,800,892.30	$2,260,131,360.97	$4,439,415,662.52	$4,520,262,721.95	$2,422,847,568.78	$562,359,720.44
2045	$153,732,458.18	$2,212,890,132.02	$4,346,623,068.54	$4,425,780,264.05	$2,396,117,161.01	$556,652,131.66
2046	$162,732,469.96	$2,187,540,854.27	$4,296,831,280.93	$4,375,081,708.54	$2,369,249,362.31	$550,917,342.21
2047	$171,711,310.82	$2,141,474,549.78	$4,206,346,507.70	$4,282,949,099.55	$2,342,266,776.19	$545,158,259.60
2048	$180,678,946.70	$2,116,285,286.57	$4,156,869,025.30	$4,232,570,573.13	$2,315,190,985.26	$539,379,177.83
2049	$189,637,275.59	$2,071,404,260.38	$4,068,712,410.14	$4,142,808,520.76	$2,288,042,587.58	$533,581,758.59
2050	$198,530,083.05	$2,046,431,941.74	$4,019,661,056.57	$4,092,863,883.47	$2,260,841,231.92	$527,769,758.09

5.5. Maintenance

Most of the coding is implemented in an Excel worksheet embedded in the FUND Access-based database application. Therefore, adding new projections are straightforward. To begin, the projections must be completed in the Excel workbook along with any graphs to be displayed to the user, and added into the respective Access form. Using the “Inputs” sheet in Excel, each of the cells for required numeric inputs should be referenced from here in order to generate the projection calculations. As for the Access-based

database, the additional input questions should be added according to the mechanism being projected. These questions can first be coded into the "Questions" table, and given a correct ordering, q_code, and answer type. (The technical appendix describes the respective table structures). Then, if it is a numerical or categorical answer, an entry in the "placement" table should relate the Excel document with the Access database. If the answer is categorical ("selection"), each possible answer needs to be included in the "q_answers" table.

Including new projections is straightforward, but each step must be carefully performed in order to link the correct questions, answers, inputs, and outputs for each projection. Additional projections could incorporate any of the current funding mechanisms or potential new mechanisms of interest to a DOT. For example, parking fees, tolling changes, and import fees could be viable mechanisms for projecting into the future.

6. APPENDIX A: FUND DATABASE TECHNICAL NOTES

FUND V3 is a database of innovative financing and funding mechanisms that is hosted in Microsoft Access 2016. Microsoft Access facilitates the storage of data, querying, and also the user interfaces that comprise the application query interface. Excel workbooks can even be embedded in an Access file and displayed in the user interface. These are held together with Visual Basic for Applications (VBA) scripts. All of these are composed of a single ".accdb" Access database file that does not require network resources or external dependencies. (The exception to this is the optional "Bootstrap" stylesheet that modernizes the display of questions within the user interface). This allows FUND to be distributed through a variety of means: thumb drive, e-mail attachment, cloud storage space—similar to how a standalone Word or Excel file may be shared within an organization.

6.1. Tables

There exist tables and functionalities that are modified within the application based on user interactions. These include:

- Profiles, which can be created by the user and denote sets of answers. These are stored within the "profile_types" and "profiles" tables.
- Answers given to questions, which are recorded when a "Save" or "OK" operation is performed on a question module screen. These are stored within the "q_answers_given" table.

This section serves as technical documentation for the table structures used to store and convey funding and financing data, as well as coefficients and weights that are leveraged for the decision tree processes.

Table profile_types:

```
profile_type integer PRIMARY KEY,
profile_title varchar
```

This represents and enforces the different profile types, as noted in the "profile_type" field printed in the description for "Table profiles" next.

Table profiles:

```
profile_id integer SERIAL PRIMARY KEY,
profile_name varchar,
```

```
profile_type integer REFERENCES profile_types (profile_type),
default boolean,
notes varchar,
UNIQUE (profile_name, profile_type)
```

This is a general profile storage table that can be used to manage profiles for Globals, Project, Questionnaire, and other question modules that may appear in the future.

- **profile_id:** Automatically generated unique ID
- **profile_name:** Visible name given to the profile. If it is "Default", it cannot be deleted, and we can have extra questions for when the user tries to update default values.
- **profile_type:** This will be:
  - 1: Projection input
  - 2: Project (used for Appropriateness)
- **default:** If this is set to true, then the UI will prevent this profile from being deleted, and will ask an extra confirmation if the user attempts to save updated answers for it.
- **notes:** Free-text for the user to store notes attached to the profile

The database is set up in such a way that if a profile is deleted, then all dependencies on it (e.g., answers that were given for a profile that are stored in the "q_answers_given" table) are removed. (It is also possible to consider a "hidden" Boolean field to hide the entry from view, which could be handy if it is necessary to maintain dependencies in the database without allowing the profile to be visible.)

Table key_types:

```
key_type integer PRIMARY KEY,
short_name varchar
```

This table helps in establishing and enforcing key types. Preset key_types are noted in the Table keys below.

Table keys:

```
key_code varchar PRIMARY KEY,
key_type integer REFERENCES key_types (key_type),
ordering numeric,
key_title varvhar,
key_notes varchar
```

This table holds unique identifiers that pertain to Mechanisms, Questions and Answers, and other types that may be needed in the future.

- **key_code:** The unique identifier. It is helpful to label the identifier in a shorthand fashion so that it hints at the type of element it pertains to. For example, precede all mechanisms with "m_". This unenforced convention began in V2 of FUND.
- **key_type:** This says what data the identifier represents. This includes:
  - 0: Unassigned
  - 1: Mechanism
  - 11: Answer
- **key_title:** Short display text for the key type
- **key_notes:** This is an optional, internal memo of what the key is for. It could later be used in the UI of necessary.

- **ordering:** Affects the appearance of the key_code with respect to other key_codes, in case a UI is designed that requires it.

Table mechanisms:

```
mech_code varchar PRIMARY KEY,
pros varchar,
cons varchar,
refs varchar
```

The fields are as follows. Each row represents a unique funding or financing mechanism, or variation on another mechanism, and has the capability of appearing as a result within the Results screen.

- **mech_code:** A short, unique code that identifies a funding or financing mechanism
- The mechanism name comes from the key_title field in Table keys
- The description comes from the key_notes field in Table keys
- **pros and cons:** Narrative that appears within the Results screen
- **refs:** Narrative that appears within the Results screen, formatted with "<A>" and "</A>" surrounding hyperlinks that are to be made active within the user interface.

Upon import, code can manage mechanisms keys.

Table q_sets:

```
q_set varchar PRIMARY KEY,
ordering integer,
q_set_name varchar,
profile_type integer
```

This defines a Question Set, which is a group of questions that are posted within a question module. Currently, a question module displays all questions for a profile, which is represented within one Question Set. However, this "q_sets" functionality is provided to allow for later expansion of multiple pages of questions or decision trees.

- **q_set:** Identifies the Question Set that this question is a member of.
- **ordering:** Unused
- **q_text_name:** Notes the purpose of the q_set; currently unused
- **profile_type:** Identifies the profile type that this Question Set corresponds with

Table questions:

```
q_set varchar REFERENCES q_sets (q_set),
q_code varchar,
q_text varchar,
ordering integer,
ans_type varchar,
description varchar,
PRIMARY KEY (q_set, q_code)
```

Each row represents an eligible question that can appear within a Question Set. These are the column definitions:

- **q_set:** Identifies the Question Set that this question is a member of.
- **q_code:** A short string that is a unique identifier for the question

- **q_text:** This text appears for the question in the Questionnaire user interface
- **ordering:** This influences the order that the question appears in, sorted from least to most from top to bottom on the Questionnaire
- **ans_type:** Determines the style that the answers are rendered in. This may be:
    - "select", which displays a list box and allows one and only one answer to be selected.
    - "dollar", which displays a text box that expects a free-form dollar amount.
    - "percent" and "numeric": similar behavior
    - "break" is treated specially for the purpose of displaying a section heading on the question list, and does not cause the respective q_code to be stored in the profile.
- **description:** This text appears beneath the "q_text" as further description on what the question is trying to ask.

Table q_answers:

```
a_code varchar,
q_code varchar REFERENCES questions(q_code),
a_text varchar,
ordering integer,
description varchar,
PRIMARY KEY (q_code, a_code)
```

Each row represents an answer that may appear in a question on the Questionnaire. These are the column definitions:

- **a_code:** A short string that uniquely identifies the answer
- **q_code:** The question identifier that the answer is associated with
- **a_text:** The text for the answer as it appears with the Questionnaire user interface element (e.g., the question list box)
- **ordering:** This influences the order in which the answers appear, in ascending order. The first item is automatically selected.
- **description:** This text appears to the right of the answers user interface element (e.g., the question list box) as help text that further describes the purpose or effects of the answer.

Table q_answers_given:

```
q_code varchar REFERENCES questions (q_code),
profile_id integer REFERENCES profiles (profile_id),
a_code varchar REFERENCES q_answers (a_code),
answer varchar,
PRIMARY KEY (profile_id, q_code)
```

This table records the answers that were given under a specific profile. Note that for "select" answers, only one answer for a given q_code and profile_id should appear in this table. If the question type is "select", then the value of 1 is stored in "Answer". If the question involves numeric entry, then the answer contains the value that was entered.

Table placements:

```
purpose varchar,
key varchar,
sheet integer,
```

```
row integer,
col integer
```

This facilitates the automation of values to be inserted into an embedded Excel workbook. For example, answer codes can be specified in “key”, and then directed to insert the corresponding value into an Excel workbook at the respective “sheet”, “row” and “col” locations. (These are addressed numerically, starting with 1). VBA methods found in the “robot” module `BulkInsert()` and `BulkRead()` use contents in the “placements” table which take “purpose” and a reference to the workbook as parameters.

6.2. Scripts and Query Functionality

While Microsoft Access is currently used as the platform for the FUND interactivity, most of the app’s functionality is implemented in VBA scripts that render local HTML and Javascript that is displayed in Web Browser controls. Further, calculations and graph renderings are performed in embedded Excel workbooks. To the end user, it appears as a traditional application that has a number of database tables on the left that can be freely accessed. Later versions may hide these. While some of the more intricate features of Access queries, macros, and data-bound user interface controls may have achieved similar results, the project team’s expertise was more in using VBA, HTML/Javascript scripting, and Excel. An advantage to using VBA and HTML/Javascript/web browser controls instead of depending upon Access-specific features and UI elements is that a majority of the scripts can be ported to other platforms, such as Excel standalone or ASP.NET with SQL Server back-end (or a vendor-independent web application), should the need arise for FUND to exist outside of Access. Most methods used for injecting contents into a web browser control and, reading out the contents of questionnaire UI elements are found in the `Formatter` VBA class.

(Let it be clarified that the HTML and Javascript running in web browser controls imposes no dependency on access to the Internet or web servers, except for the open-source Bootstrap stylesheet that is currently used to assist in making the Questionnaire and Results screens appear consistent to that of a modern application. The Bootstrap stylesheet is fetched from its default location online and may be cached on many systems because it is used on many websites. This dependency on Bootstrap may be phased out, as it had been found to not work as fully intended within the web browser control.)

SQL queries are issued from VBA to Access, but are currently fairly simple, querying to one table at a time for the sole purpose of reading contents into “dictionary” data structures. Much of this happens in the `AnswerSet` VBA class.

The structure of the code consists of small, form-specific support functions that are bound to events on each of the three forms used in the application (`Form_Title`, `Form_Questions`, and `Form_Results`), a `core_module` that contains the bulk of the calculation logic, and then `profiles` and `util` modules that support other functionality. As mentioned earlier, the `robot` module coordinates the injection and retrieval of data from embedded Excel workbooks. Please refer to the comments within the code for further indications on what subroutines and functions do.

6.3. Excel Embedding Notes

As described earlier, Excel workbooks are embedded in Access to ease development efforts and provide powerful calculations and display of outputs to users without the need for scripting. Excel workbooks may be developed independently of the Access database application. These notes are intended to assist in efforts to update the Excel-based functionality.

Excel workbooks already embedded in the Access application may be edited in-place by accessing the Design View of the form that contains it, right-clicking on the Excel control, and then choosing "Worksheet Object" -> "Edit" or "Open". "Edit" will allow the contents to be tweaked inside the form, and "Open" offers more of a traditional editable view of the contents within the Excel application. If using "Edit", clicking outside of the contents area or pressing the ESC key will end editing and return to the Design View; the same can be achieved if Excel is closed after it is accessed through "Open". Saving the database or closing the Design View will allow for changes to the embedded workbook to be saved to the Access file.

If a worksheet is being created or edited outside the control of Access, it is necessary to go through a process to embed it into FUND when it is time for FUND to use it. To do this, make note of the control name within the Design View of the respective Access form. Then, delete the old control. Next, drag and drop the Excel .xlsx file from Windows File Explorer into the Design View form. Finally, rename the newly-formed control to the name of the old control. The existing Excel controls are referenced from VBA already in the `Form_Projections.Populate()` subroutine (`Form_Projections .oleProj`) for Projections, and `core_module.CalcResults()` subroutine (`Form_Results _Details.oleAHP`) for Appropriateness.

When embedding, Access' behavior around zooming and clipping the visible contents of Excel sheets is confusing and requires some experimentation. The key to remember is that *at the time of embedding*, the extent of populated cells on the visible sheet at the time the workbook is most recently saved is the guide to Access for determining where the desired screen content is located. Ensure that the screen area populated by cells on this sheet is also the desired screen area for all of the other sheets that are to be displayed. Anything outside the screen area of these populated cells will be cropped. Conversely, ensure that all cells outside of this desired screen area are completely empty (e.g. clear them by deleting); otherwise, whitespace or recently edited (but cleared) cells will cause undesirable whitespace to appear around the desired screen area. Finally, consider using "Zoom" for the "Size Mode" setting in the Access Design View for the form that contains the embedded worksheet to allow the desired screen area to fill the area defined by the control's bounds. Remember also to set the size of the form to a size that will fit most monitors, as the size may automatically be grossly increased when following the embedding process.

Two other Access Design View options may be relevant for using embedded Excel workbooks within the Access database application. These are the "Enabled" and "Locked" options. If "Enabled" is "No", and "Locked" is "Yes", then the workbook appears but cannot be interacted. However, if "Enabled" is "Yes", and "Locked" is "No", then the user can double-click on the workbook, and save it or copy-and-paste contents to another application. Although there are few things that can be done to prevent the user from editing the contents of the workbook, the ability to enter into it can be powerful for allowing contents to be copied to a report or e-mail quickly. Further, unless Design View is engaged, any changes made to the workbook are forgotten when the respective Access form is closed.

The Projections workbook contains several pages that are toggled from within Access. Making this work properly was surprisingly difficult, as no clear methodology for toggling Excel sheets from Access VBA was successful or obvious when trying to figure out how to accomplish it. Inside the `Form_Projections.ShowProjection()` subroutine, the solution was to activate and set "permanently" invisible all sheets that are not the one that is to be displayed. For this reason, it is important to not save the Projections form after a page change operation is executed without closing and

re-opening that form first to reset the embedded workbook. Otherwise, manually unhiding sheets from within embedded Excel is a cumbersome process.

Attention needed to be given to the speed of injecting values from the Excel sheets, especially with the intensity of AHP calculations. The only obvious method for injecting values to Excel were to access cells one by one, as seen in `robot.BulkInsert()`. By default, Excel recalculates everything after each cell is updated, resulting in a prohibitively lengthy wait for AHP to complete. The solution was to disable automatic calculation within the Excel sheets (via, for example, the "Calculation Options" drop-down in the "Formulas" ribbon of Excel 2019). Then, after all cells are updated, the `.calculate` method is called at the end of `robot.BulkInsert()`. Meanwhile, hiding the Projections workbook while it was updated accelerated that process slightly and prevented the display of a rapidly shifting chart.

7. APPENDIX B: SAMPLE SURVEY

An Expert Panel Survey can be conducted with the objective of expanding the knowledge base represented in the FUND Access database. The survey's main goal is to leverage the expertise of a panel of experts to determine how different characteristics of funding mechanisms align with the different criteria for funding, such as reliability, user equity, ease of implementation, or predictability. As this section details, the survey is designed to assist in weighting qualitative and quantitative aspects of funding and financing mechanisms in the project's database.

The Expert Panel Survey consists of four different project examples (or "types"), each of which help to represent extreme characteristics so one can determine how each of the criteria are connected to each of the characteristics. The criteria scoring mechanism is previously described in Section 4.2.

This sample Expert Panel Survey is located within the repository as:
`expert_panel_survey_sample.doc`.

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