Pacific Northwest
NATIONAL LABORATORY

TRANSACTIVE SYSTEMS PROGRAM

VALUATION OVERVIEW | MARCH 2021


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INTRODUCTION TO **TRANSACTIVE ENERGY VALUATION**

The valuation methodology developed at Pacific Northwest National Laboratory under the Transactive Systems Program models value exchanges within a system. This methodology incorporates principals of e3 Value Models—identifying and analyzing value streams through graphic notation—but is expressed with the Unified Modeling Language (UML)[1]. While the valuation methodology was originally developed to support analyses of transactive energy systems, its applicability is vast, lending itself to many research studies concerning complex energy systems.

Many analyses of technical systems focus on the operational success of the system with economic assessments remaining a secondary focus. As such, the economic portion of the research study is not addressed until the system has been designed and the technical analyses have been completed. However, this process limits the usefulness of the economic analyses as the data necessary to complete them are often unavailable. This hinders the adoption of these technologies in practice as business cases, equity impacts, and individual outcomes need to be evaluated before they are implemented.

Thus, while the valuation methodology is its own unique process, it is essential to embed the framework into the overall research process. Valuation should be considered while a study's analysis is being designed, but it should also resurface during any preliminary analyses that are conducted to test the system and the final system analysis. This ensures the system analysis is cohesive with and supports the economic analysis modeled through the valuation methodology.

To employ the valuation methodology, analysts are tasked with the following:

- understanding the system
- identifying where and between whom value exchanges take place;
- defining required metrics;
- ensuring the necessary data to compute metrics are collected;
- informing and refining study objectives; and
- modeling those values within system operations.

Naturally, this is an iterative process that requires coordination across different members of a project team to ensure the resulting valuation model reflects the reality of the system. **Figure 1** shows the general order of operations required to produce a value model; the process is nonlinear with many steps taking place simultaneously or requiring previously completed steps to be revisited.

The primary goals of employing the valuation methodology are to create a comprehensive approach for granular economic assessments that is embedded within a project's larger objectives and identifies key data requirements for calculating the metrics necessary to draw conclusions from a study. In order to achieve these goals, the valuation process needs to be established at the early stages of a project.

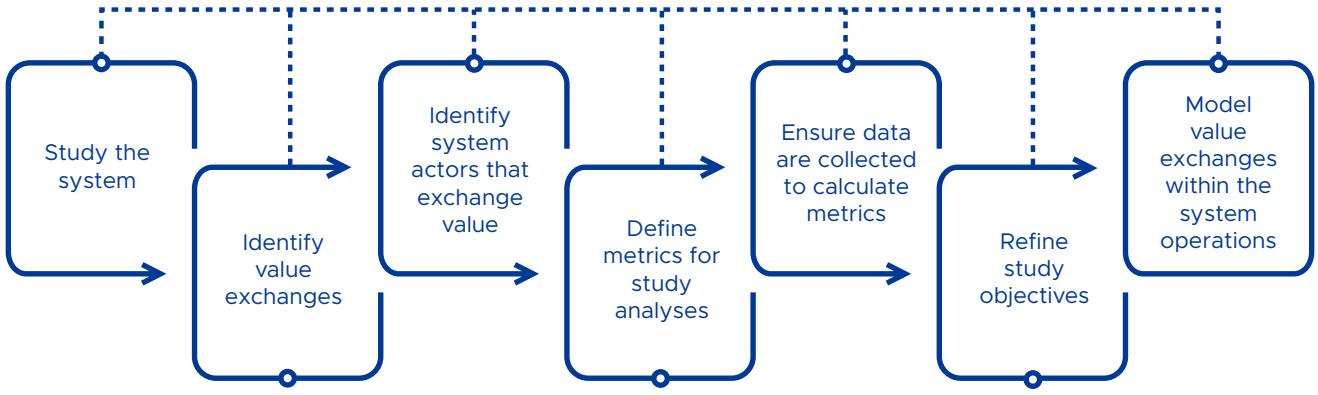

Figure 1. Valuation Methodology Process

[1] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL26127.pdf

THE VALUE MODEL

Subject matter experts often develop models of complex technical systems that are only well understood within the group that created them. However, as is the case with transactive energy systems, stakeholders involved in adopting and utilizing those systems may not have the specialized knowledge needed to decipher those models. Visual models, like the example shown in **Figure 2**, conceptually depict a system and are key to bridging that divide. In particular, the models developed within the valuation methodology provide a conceptual depiction of the system in tandem with the specific value exchanges that occur through UML diagrams. UML diagrams allow for increased transparency for both the internal research team and the audience of the finished study. The diagrams quickly clarify what assumptions researchers make about the system and the structure of the value exchanges in UML leaves little room for misinterpretation. Since transactive energy is a market-based economic coordination and control technique, valuation has become a critical piece of the research studies. The value modeling concisely shows the value exchanges that will be simulated or deployed; this is beneficial to those building the simulation, those implementing the deployment, and to those studying the research once it is completed.

The example in **Figure 2** shows a simplified example of some of the artifacts of the valuation methodology, specifically the value model and accounting table. This example analysis is modeling the SGIP1a scenario[2] and shows multiple distribution feeder systems (A-E) with increasing amounts of DER available. The DERs modeled are a photovoltaic solar system, battery energy storage, and an air conditioner equipped with a transactive controller. Each system is modeled for two days, one under normal conditions and another where outages occur.

Shown in Figure 2 are the entities modeled in the analysis. Figure 2 also informs which entities are not included in this analysis. For example, there is no independent system operator shown in the value model, so one could assume it is not included in the analysis. The model also shows what values are not part of the particular analysis. Though it could be in other studies, this study isn't tracking the trade-off in money for comfort by the customer. Additional value flows could be shown to model a more complex analysis that takes into account other values, such as comfort and emission reductions. For this example, the value model captures all systems (A-E) for both the normal and outage days and only quantities of values are expected to change between these cases—which would be captured in the accounting tables. The business case for the distribution utility in this analysis can be seen by summing the value flows associated with it; the value model directly informs accounting tables where those business case calculations are made.

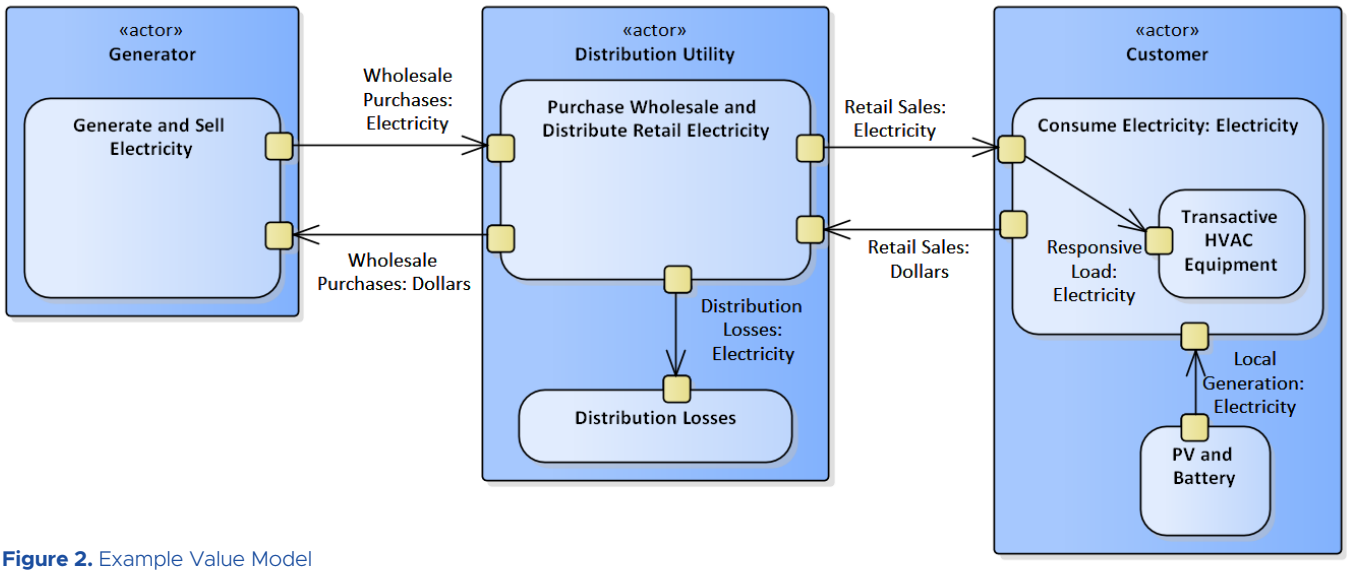

Figure 2. Example Value Model

[2] https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26409.pdf

THE ACCOUNTING TABLES

The accounting tables have line items for each relevant value exchange to a system actor. These tables not only provide the business case for each actor but also show how each value exchange contributes to the business case. If a stakeholder were to reference an accounting table and found a value exchange that was modeled differently than their reality, they may consider an alteration that modifies or excludes that value stream to understand their potential business case. The combination of the accounting tables and the UML diagrams creates a portfolio of documentation to support granular economic analyses. **Table 1** shows the accounting table for the distribution utility shown in Figure 2.

The value model in Figure 2 informs the generation of the accounting tables, where the values will be reported once calculated in the analysis. The business case of the distribution utility under the different system configurations (A-E) and days can be seen.

From this table, researchers can work to identify specific data needs to calculate the desired metrics. For example, one of the desired metrics may be the difference in the retail electricity purchases paid to the distribution utility. The first step would be to make sure that value is included within the value model and accounting table. Then, the data inputs and sources for calculating that value would be identified. This is when valuation starts to inform and coordinate with the simulation within a study. Valuation would identify that through simulating certain data that need to be generated and captured in order to calculate this metric and complete the desired analysis.

Distribution Utility: Purchase Wholesale and Distribute Retail Electricity	SYSTEM A		SYSTEM B		SYSTEM C		SYSTEM D		SYSTEM E	
	Day 1 (Non-outage day)	Day 2 (Outage day) Diff from Day 1	Day 1 (Non-outage day)	Day 2 (Outage day) Diff from Day 1	Day 1 (Non-outage day)	Day 2 (Outage day) Diff from Day 1	Day 1 (Non-outage day)	Day 2 (Outage day) Diff from Day 1	Day 1 (Non-outage day)	Day 2 (Outage day) Diff from Day 1
Revenues/Incoming Values										
Retail electricity sales revenue for test feeder ($/day/customer)										
Wholesale electricity purchases for test feeder (MWh/day/customer)										
Expenses/Outgoing Values										
Retail electricity sales for test feeder (MWh/day/customer)										
Wholesale electricity purchase cost for test feeder ($/day/customer)										
Distribution losses (MWh/day)										

Table 1. Example Accounting Table

The granularity provided by valuation helps stakeholders understand which aspects of the results are relevant to them and answer larger questions about equity within a system. For example, if a system produces a total net benefit but certain actors within the system consistently realize lower magnitudes of value at an individual level, those discrepancies will be identified rather than hidden in the positive economic outcome of the entire system.

CONCLUSION

Many engineered systems and simulations are built for functionality and have hidden innerworkings. Even when systems are thoroughly documented, they are not always digestible across the range of disciplines that interact with the system on different levels. Designing a functioning system without understanding the effect on the value for those involved does not ensure buy-in, investment, and widespread adoption of the system. Many stakeholders (e.g., financial, political) require an understanding of the impact of the system in order to support its implementation or development.

In order to calculate any of the economic assessments that the valuation methodology enables, it is critical to coordinate with system designers and modelers to ensure necessary data are being collected. Throughout the valuation process it is important that data requirements to calculate the desired metrics are identified. The identification of data needs prior to the simulation and field demonstrations being developed is necessary to ensure all of the required data will be generated or collected at some point during the study, making the analyses possible. Integrating the valuation related metrics and data needs at the same level of rigor as the engineering ones in the simulation and field demonstrations requires specific identification of potentially new data needs early on because it may lead to significant changes in how the study is conducted.

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