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Investigating the Effect of Refinancing on Financial Behavior of Energy Efficiency Projects

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Abstract**—**Reduction of energy consumption in built infrastructure, through the installation of energy-efficient technologies, is a major approach to achieving sustainability. In practice, the viability of energy efficiency projects strongly depends on the cost reimbursement and profitability. These projects are subject to failure if the actual cost savings do not reimburse the project cost promptly. In such cases, refinancing could be a solution to benefit from the long-term returns of the project, if implemented wisely. However, very little is still known about the effect of refinancing options on financial performance of energy efficiency projects. In order to fill this gap, the present study investigates the financial behavior of energy efficiency projects with focus on refinancing options, such as Leveraged Loans. A System Dynamics (SD) model is introduced, and the model application is presented using an actual case-study data. The case study results indicate that while high-interest start-ups make using Leveraged Loan inevitable, refinancing can rescue the project and bring about profitability. This paper also presents some managerial implications of refinancing energy efficiency projects based on the case-study analysis. Results of this study help to implement financially viable energy efficiency projects so that the community could benefit from their environmental advantages widely.

Keywords**—**Energy efficiency projects, leveraged loan, refinancing, sustainability.

I. Introduction

GROWTH in human population and economic development strain the finite natural resources such as land, water, materials, food, and energy. To maintain, and improve the quality of life, we need to develop. By enhancing sustainability, we will preserve essential, natural, economic, and social resources for the sustenance of future generations. In recent years, the priorities of building industry have come to change due to these newly-aquatinted needs, especially in terms of energy. Conserving the available natural resources by minimizing building footprints is a key driver of this. Energy consumption, due to its environmental effects such as resource shortage and air pollution, is the focal point of this view [3], [5].

Construction of energy efficient buildings is a solution to meet this objective. The Leadership in Energy and Environmental Design (LEED) program conducted by U.S. Green Building Council is an example of sustainability efforts, which pursue the integration of sustainability values in building construction. Although effective in a long term, these efforts do not address the problem of energy waste in buildings constructed prior to initiation of such programs, which is also crucial to sustainability objectives. The reduction of energy use in built infrastructure by using energy efficient devices to prevent energy waste is a solution to this problem, known as Energy Efficiency measures. However, there are some obstacles, especially financial ones, in implementing Energy Efficiency projects [1], [6].

Like any other projects, the financial aspect of Energy Efficiency projects is very important. In fact, a trade-off between cost and benefit of the project determines whether the project is attractive enough to be implemented. There are many governmental, state and other non-profit organizations such as U.S Environmental Protection Agency, which provide various financing options, such as tax-exempt or low-interest loans, to facilitate initiation of Energy Efficiency project. However, it is still crucial for decision makers to be aware of the potentially quantifiable benefits and opportunities from improved building energy system, especially when the Paid-From-Saving concept is implemented for the fund (loan) repayment. Savings due to lower energy consumption in the future is a justification for feasibility of Energy Efficiency projects. Nevertheless, because of long-term return on investment and uncertainty of the savings, making such a financial decision is not easy for facility managers unless a clear perspective of the project financial behavior is available [1].

II. Problem Description

The complex and dynamic structure of future savings and payments along with the ambiguity of the results prevents facility managers to start Energy Efficiency measures in built infrastructure. The big question for every facility manager is whether future savings from lower energy consumption can compensate for the start-up loan repayment. In this regard, giving a clear perspective of financial behavior of Energy Efficiency projects, and conditions and strategies under which the projects can be led to success is an essential step towards sustainability and environmental objectives.

The TAMU Sustainability Fund project is a successful example of such Energy Efficiency projects. Although its success can be an incentive to initiate similar sustainability projects, it is very important to notice that it was a special case of funding Energy Efficiency projects, at which a low-interest loan was available, and the minimum amount of savings was guaranteed by a contract. Facility managers usually need to make decisions based on more complex situations in which such a low-interest loan is not always available. In fact, the managers, who seek initiation of sustainability projects, need

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to know financial consequences of using conventionally available loans with different conditions.

Regarding the importance of clarifying the financial behavior of such sustainability projects, in a recent research conducted by Kim et al. [1], the researchers investigated the financial behavior of TAMU Sustainability Fund project using System Dynamics methodology. The project was financed by a revolving loan Equal to $10 million provided by Texas State Energy Conservation Office (SECO) at 2% annual interest rate with 10-year payback period. TAMU is supposed to return the loan from future savings due to energy conservation. This payback structure (Paid-From-Saving) is a common practice among some U.S. universities that pursue sustainability objectives [4]. Results of their work showed the project would not have any problem in loan repayment and also would result in great savings (about $10M after 200 months) under the contract conditions, that is $10M start-up loan at 2% annual interest rate and 10 years payback period while the minimum amount of savings is guaranteed by the project partner (Siemens).

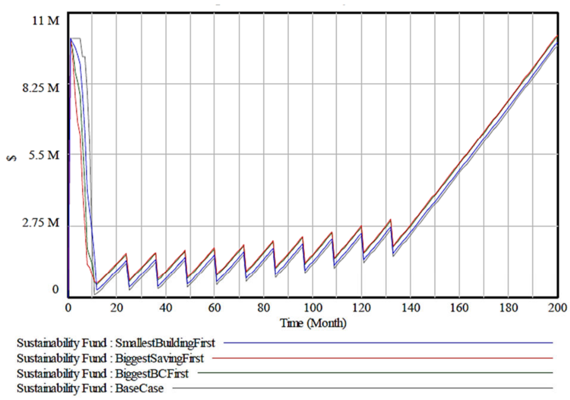

Fig. 1 Behavior of the Sustainability Fund under different ordering policies [1]

The research conducted by Kim et al. [1] is limited to the project contract conditions and consequently does not answer a big question concerned with such sustainability projects in general: If such a low-interest loan was not available, would the project lead to success, and if so, how much would the savings be? Obviously, the project success would be dependent on whether the energy saving is enough for the loan payment. The annual loan payments are determined by loan conditions; that is the loan interest rate and the payback period. So if the loan conditions change, for example, the loan interest rate goes up, the annual payments increases which would result in decreasing the total saving or even failure of the project due to inability to reimburse the loan. TAMU is a public university with strong financial support from the state. But there are a lot of private universities that might be interested in the initiation of such sustainability programs both with environmental and financial incentives. It is most likely that the available start-up loans for them are different from TAMU. They perhaps need to decide whether start such projects using loans with higher interest rate dictated by the market or not. Also, it is possible that the whole required fund is not available for them even at higher interest rates [2]. Investigating these more complex conditions based on the experience of TAMU Sustainability Fund project is the focus of this research. In this regard, this research seeks to answer the following question:

- What is the impact of other financing conditions (other than the TAMU Sustainability Project loan from SECO) on the performance of the sustainability fund?

To answer the above question, the following sub-questions will be investigated in this study:

- What is the impact of the different interest rates of start-up loan on the performance of the sustainability fund (its ability to reimbursing the loan and the amount of savings)?
- How the performance of the sustainability fund changes if the whole required money is not available (change of start-up loan) under different interest rates?
- What is the effect of different policies in buildings improvement order on the performance of the sustainability fund [1]?

The above problem will be investigated under two conditions:

A. The minimum guaranteed savings in the contract of TAMU Sustainability Fund project will be considered to calculate the sustainability fund.
B. The actual energy savings of the project in the last years (after completing the project) will be considered to calculate the sustainability fund.

The TAMU Sustainability Fund project was completed in 2011. The energy consumption of the project buildings for the past two years is available, which has been used in this study.

Integrating the actual data and comparison of the results with the contract data will give valuable insight to how well or worse such projects work.

III. Background and Data Collection

This study is an extension to the research work by Kim et al. [1], to address a gap in knowledge and answer a question uninvestigated in their work. They tried to clarify the financial behavior of TAMU Sustainability Fund project using System Dynamics methodology. As mentioned before, the project had a start-up loan of $10M at APR 2% with a payback period of 10 years. The loan payments were scheduled annually starting after the second year (first payment in month 24).

TAMU Sustainability Fund project involved improving 17 campus buildings under a contract with Siemens. The project started and completed in the calendar year 2011. The contract mainly included upgrading of the building-automation system (e.g. installing sensors tied to controllers of HVAC equipment to minimize air flow during unoccupied periods) and lightening retrofits (e.g. replacing inefficient lamps with more energy efficient ones). Siemens guaranteed a minimum energy saving for each improved building. The energy consumption records of the buildings in 2009 were the baseline for energy conservation calculation in the contract.

Kim et al. [1] used the contract information to model the financial structure of the TAMU Sustainability Fund project and address the following questions:

- What is the impact of project scheduling on the performance of sustainability fund?
- What is the impact of financing structure on the performance of sustainability fund?

To answer the first question, they investigated three different prioritizations in the project scheduling to find the strategy aiming higher cumulative saving after 200 months including; (1) Descending order of total savings, (2) Descending order of Benefit/Cost ratio, and (3) Ascending order of improvement cost.

They also considered two financing strategies; (1) the fully funded case in which all the required fund ($10M) was available, and (2) limited funded case in which only half of the required fund ($5M) was available. The original loan conditions (APR 2% with a payback period of 10 years) were applied to both cases. Their work revealed that the best strategy was to improve all buildings at once prioritized based on the savings amount (biggest saving first) in case the whole fund is available. In case of partially funded project ($5M), the best policy was to improve buildings in descending order of Benefit/Cost ratio.

The model built by Kim et al. [1], using Vensim®DSS software, reflects the mentioned Energy Efficiency program (TAMU Sustainability Fund project). The model has three primary stocks; Building Energy Savings, Sustainability Fund, and Invested in Building. The Model initiator is the incoming fund from an external source (start-up loan). As quick as the flow of incoming fund starts, the funds accumulate in Sustainability Fund stock. When the Sustainability Fund stock reaches to the adequate funding to improve the first building, the funds are taken out of the stock to improve the first building. This step is repeated till all seventeen buildings are improved. Improvement of buildings causes the energy consumed in each building decreases. Accordingly, the decrease in energy consumption leads to increase in energy savings. Finally, these savings return to the Sustainability Fund to be paid for loan payments or improvement of the next buildings.

As mentioned above, two financing strategy is considered in the research done by Kim et al. [1]. In the first strategy, the $10M start-up loan is available for the project and all 17 buildings are improved within a year. As fast as each building is improved, energy saving gets started and accumulate in the Sustainability Fund. The loan payments begin 24 months after the project initiates and are deducted on a yearly basis (i.e. months 24, 36, 48, etc.). In this scenario, the Sustainability Fund shows the same behavior mode for all three prioritization policies although it has different balances during the project period and at month 200. Moreover, the research shows that all three prioritization policies have better result comparing to the base case. The base case reflects the order of building improvement according to the contract with Siemens.

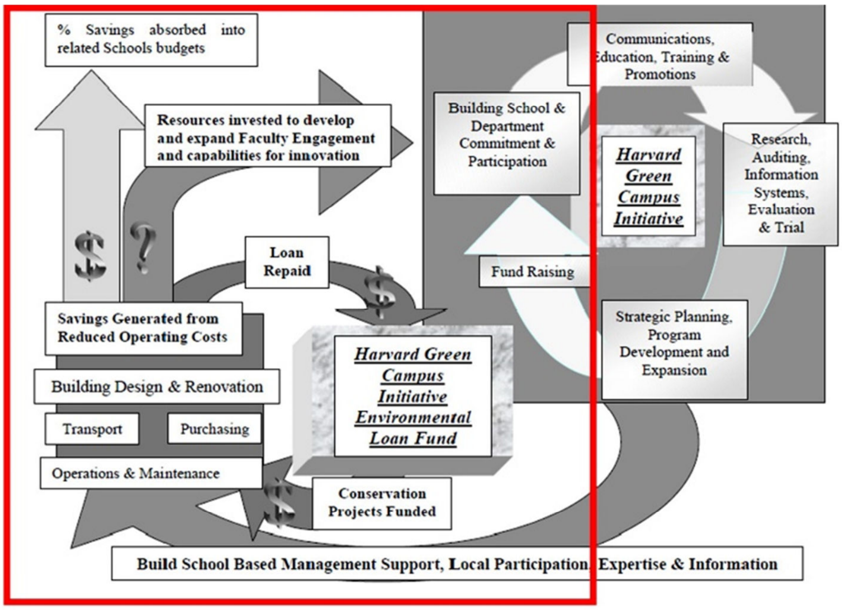

Fig. 2 Structure of Harvard Green Campus program [1]

In the second financing scenario, when the adequate fund is not available, the project cannot proceed with improving all the buildings within the first year. The remained buildings get improved one by one as fast as the availability of the adequate saving in the Sustainability Fund, without considering that whether the remained saving will be enough for the loan repayment or not. Therefore, the Sustainability Fund shows negative values in some repayment due dates. This issue exists in all prioritization policy when inadequate start-up loan is available. The researchers have assumed that as far as these negative values are covered by energy savings in a short period they can be ignored, implying the project has a financial supporter to pay for its debts. However, it is more reasonable to assume that no remained building gets improved unless the owner is sure that the Sustainability Fund can afford loan payments promptly. In other words, loan repayment is the priority for the Sustainability Fund [1].

Kim et al. [1] has referred to Harvard Green Campus program as the conceptual model of the TAMU project. The structure of this model is illustrated in Fig. 2, and the formal model structure of the previous research is shown in Fig. 3.

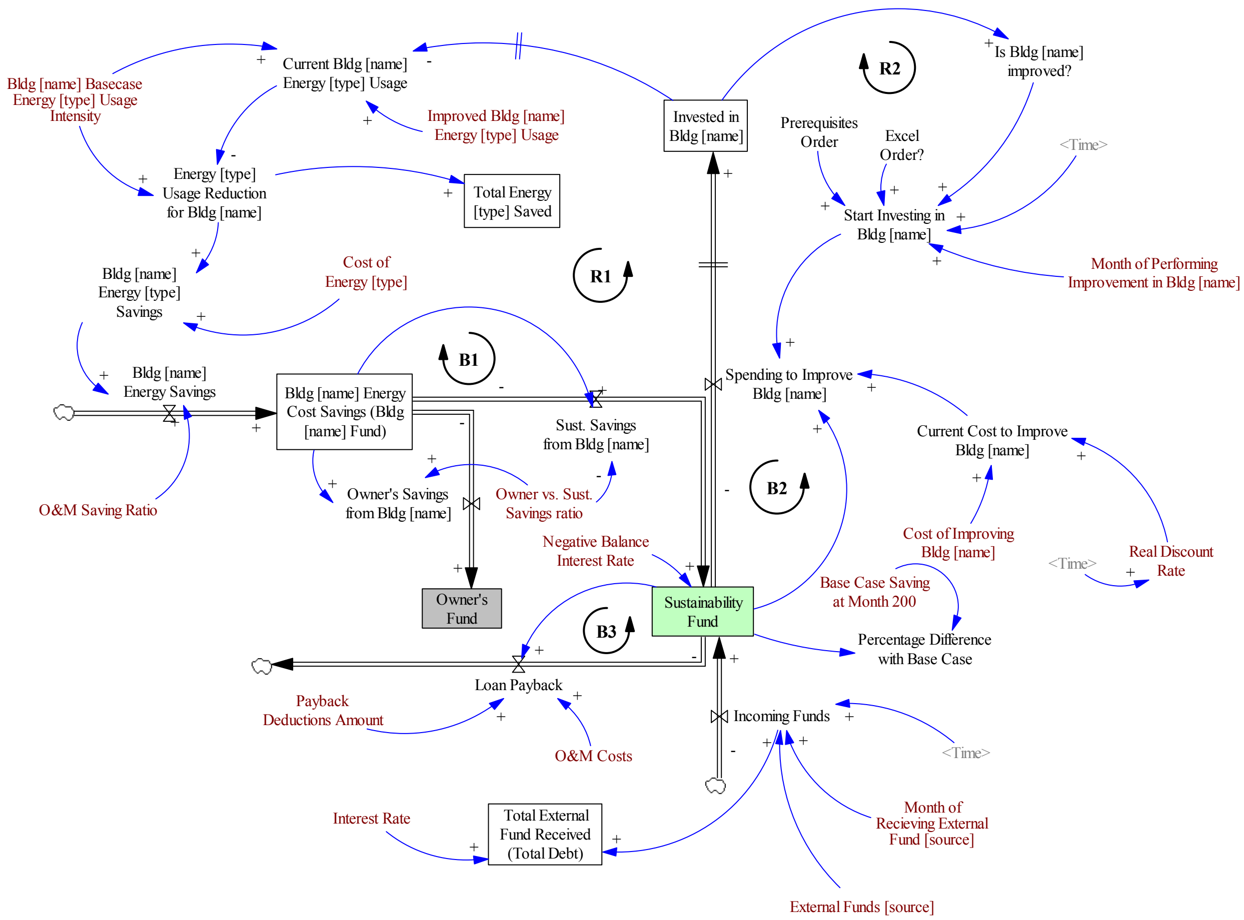

Fig. 3 Formal model structure of [1]

This model has three balancing loops (B1, B2, and B3) and two reinforcing loops (R1, and R2). The descriptions of these loops are as follows:

- R1: an increase in "Sustainability Fund" leads to increasing in "Spending to improve Bldg" which causes "invested in Bldg" to increase, indicating that buildings were improved. "As the number of improved buildings goes up the "Current Bldg Energy Usage" reduces and results in increasing "Energy Usage Reduction for Bldg". Increase in "Energy Usage Reduction for Bldg" causes "Building Energy Saving "to increase for each type of energy. Accordingly, "Bldg. Energy Cost Saving (Bldg Fund)" and "Sustainability Fund" go up.
- R2: This is a structure devised to determine the order of which the buildings will be improved. As the first building is improved, it allows the next building to improve and so on.
- B1: Sustainability saving from buildings is the amount of money taken out from "Bldg. Energy Cost Saving (Bldg Fund)" and put into "Sustainability Fund". Therefore, increase in "Sust. Saving from Bldg" results in the decrease in "Bldg. Energy Cost Saving (Bldg Fund)".
- B2: When there is adequate budget available in "Sustainability Fund", then "Spending to improve Bldg" deducts from the "Sustainability Fund".
- B3: When there is sufficient budget available in "Sustainability Fund", "Loan Payback" cause "Sustainability Fund" to decrease.

During the current study, original model was improved and expanded to be able to answer this research focusing question. The data used to extend the model is the same as the data used for the base model. The former researchers shared the data they used including buildings information, energy consumption data, contract data, etc. with us as well as their

Vensim® model. Also, the data of the buildings' actual energy consumption after completing the Energy Efficiency project, required for the last part of this research, were obtained from TAMU Utility and Energy Service. The data is available for two fiscal years of 2012 and 2013 [1].

To answer the focusing question of this research, the original model, described above needs to be expanded. In fact, the original model is unable to capture what in reality happens in when rather high-interest loans are available to start the project. The problem is that when higher interest rates are applied, and so the annual loan payments increase to higher amounts the Sustainability Fund in the original model gets negative values for rather long time. In these cases, although the Sustainability Fund may finally become positive due to future savings, the project is bankrupt (failed) in fact. In the real world when an entity is unable to pay back a loan for a considerable time it forfeits its possessions.

The values of the Sustainability Fund in the original model when an interest loan of 7% is applied to the $10M start-up loan was shown in Fig. 4. As can be seen, although the graph shows a total saving of more than $6M at month 200, the project has failed before. The reason is that it can pay only the first two annual loan payments, and after that there is not enough money in the Sustainability Fund to pay annual payments and the sustainability fund gets very large negative values, implying large debts. In addition, between around month 85 and 150 (more than five years) the project cannot pay any portion of its debt. Therefore, no payment is done this period. Obviously, in these circumstances the project and its owner will not survive to gain the $6M savings. Thus, the value returned by the model at month 200 is not reliable.

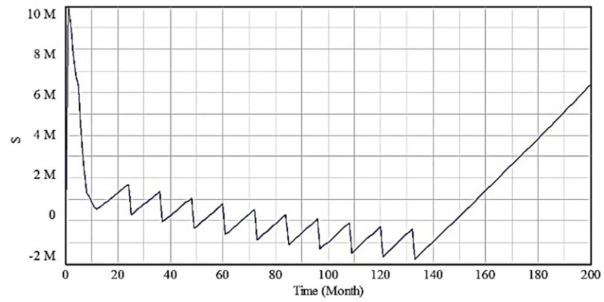

Fig. 4 Behavior of sustainability fund produced by the original model when APR 7% applies to $10M start-up loan

In a real world, the owners who face such situations try to get external funding to leverage the project and help it to survive until its profitable period. These external funding, which is called Leverage Loan in this report, is used to pay both the former loan (start-up loan) payments and its payments. Adding the structure of these Leverage Loans to the original model is necessary to find reliable answers to the research questions.

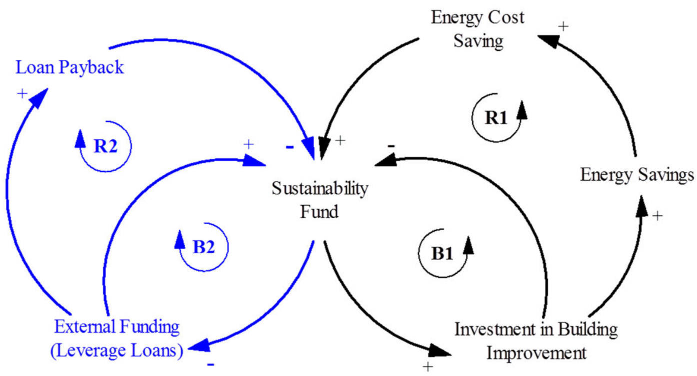

Fig. 5 Causal Loop Diagram of the improved model

A. Conceptual Model

The conceptual structure of the expanded (improved) model that includes the contribution of Leverage Loans (additional external funding) to the system is illustrated in Fig. 5.

- R1: Increase in “Sustainability Fund” pushes more “Investment in Building Improvement”, which results in more “Energy Saving” and so “Energy Cost Saving”. More cost savings add to the “Sustainability Fund” and increase it.
- B1: Increase in "Sustainability Fund" pushes more "Investment in Building Improvement", which is deducted from "Sustainability Fund", and so reduces its amount.
- R2: When the “Sustainability Fund” goes down more “Leverage Loan” is required. Payments of the new Leverage Loan will be added to the previous loan payments and increase “Loan Payback” amount, which is paid from the “Sustainability Fund” and reduces it.
- B2: When the “Sustainability Fund” goes down more “Leverage Loan” is acquired, which will be added to “Sustainability Fund” and increase it.

Black parts in Fig. 5 represent the original model, and the blue parts represent the added section to expand and complete the model. The added section consists of a new reinforcing loop and a new balancing loop, as described in the legend of the causal loop diagram. The new feedback loops are triggered when the sustainability fund gets large negative values (debt).

B. Formal Model

To add the new feedback loops, the bottom section of the original model has been changed. In fact, very small changes have been made to the upper section of the original model, where the calculations of "building order" and "energy saved after improvement" are performed. The only change in the upper section concerns the formulation of "Spending to Improve Bldg [name]" to improve it. It is a flow variable, which takes the money out of the Sustainability Fund to improve buildings. In the original formulation, the variable takes out the money when enough funds are available to improve the next building regardless of the upcoming loan payments. This formulation sometimes results in the coincidence of loan payment and building improvement resulting in negative values of Sustainability Fund. In reality, however, this does not happen in that the managers predict their mandatory payments in the near future and prioritize their payments. Therefore, they do not allow the Sustainability Fund gets negative due to such coincidences. In the revised formulation, it is assumed that in the start-up loan payback period, improvement of buildings happen if the available money is more than the next loan payment and the money required to improve the next building [1].

Fig. 6 illustrates the expanded section of the model that represents the structure of using Leverage Loans. The new model introduces a new variable named “Credit Line”. This variable determines the flexibility of the loan provider (say a bank) when the payments cannot be made in full. For example, if somebody cannot pay $200 of his annual loan payment if the payment amount is $20,000, he will not forfeit his possession. That is because his “Credit Line” is more than $200. In fact, as far as the debt is less than the credit line he will not have any problem with the bank. But the bank perhaps wants to apply a separate interest rate on this debt. This is what has been considered in the new model as well. As far as the sustainability fund is negative but above the credit line the project does not need Leverage Loan, but an extra interest is applied to the negative balance of sustainability fund (see loop R3 in the model structure).

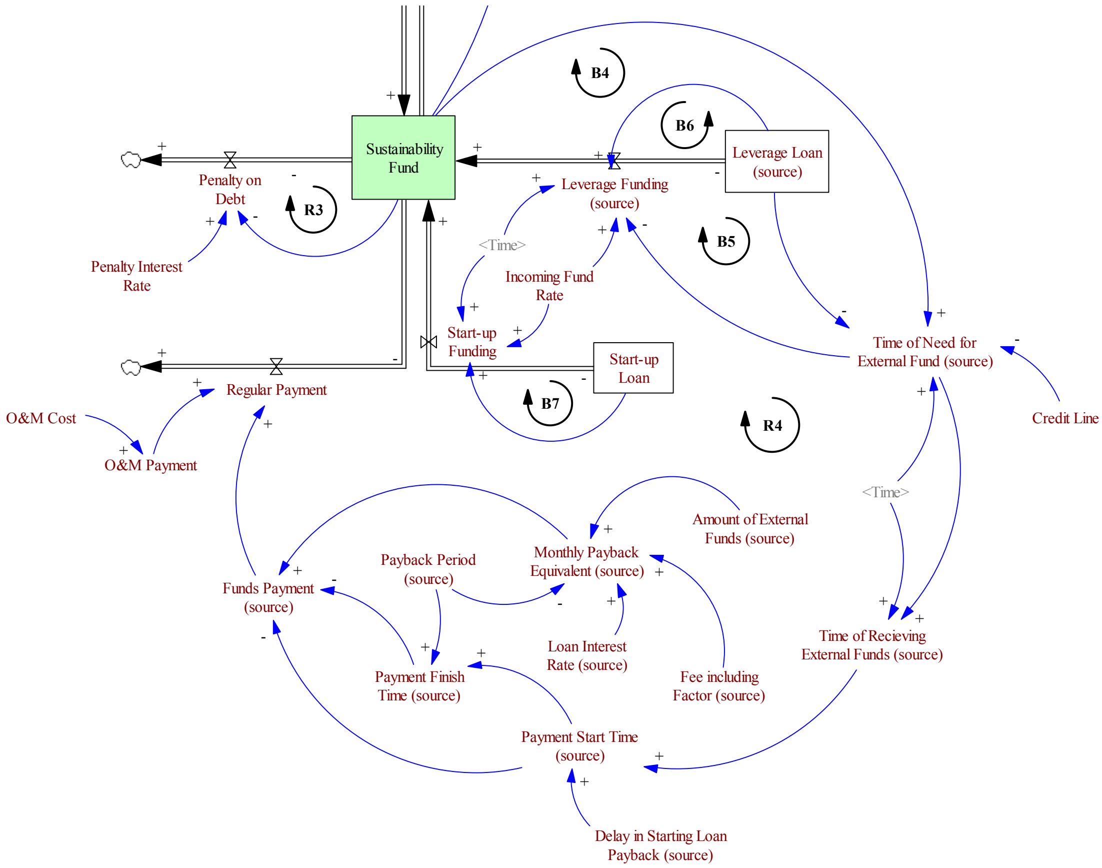

Fig. 6 Expanded section of the formal model

- R3: When the negative "Sustainability Fund" decreases (debt increases) "Penalty on Debt" increases that results in the larger negative value of the "Sustainability Fund".
- R4: When the “Sustainability Fund” goes down, “The Time of Need for External Fund” and so “Time of Receiving External Fund” go down (get closer and the Leverage Loan is received). As a result, “Payment Start

Time" occurs and the sum of "Fund Payment" and so project "Regular Payment" increases. More payments consequently decrease the "Sustainability Fund".

- B4: When the "Sustainability Fund" goes down, "The Time of Need for External Fund" goes down (get closer and the Leverage Loan is received). As a result more "Leverage Funding" is added to the "Sustainability Fund" and increases it.
- B5: When "the time of need for external Fund" goes down (get closer and the Leverage Loan is received) more "Leverage Funding" is used which pushes the time of next leverage Loan to a later time ("the time of need for external Fund" goes up).
- B6: Adding more "Leverage Funding" to the project decreases the bunch of available "Leverage Loans" which decreases the rate of "Leverage Funding".
- B7: The same concept as B6 for the start-up loan.

If the sustainability fund goes below the Credit Line, the project has faced a serious problem in that the bank will not tolerate this amount of debt, and so the project will be about to fail (bankruptcy). This is the time that the project needs Leverage Loan. In the model, Credit Line and Sustainability Fund determine the time of receiving Leverage Loan (if any). The model is capable of adding several Leverage Loans to the project at different times when the sustainability fund goes below the Credit Line. The number and time of receiving these Leverage Loans are dynamic based upon the performance of the sustainability fund, and their payment amount and due date cannot be predefined. While the original model gets predefined amounts of start-up loan payments at predefined due dates, the new model needs to do these calculations by itself. The model intelligently triggers a Leverage Loan when it is required and calculates its payment amounts, and deducts them from the sustainability fund at the right time.

The described structure reflects what happens when large payments (for example due to the high-interest rate of start-up loan) cause the financial problem for a project and how the managers treat it to survive. The response of the model under such realistic conditions is reliable to investigate the effect of different financing conditions than TAMU Sustainability Fund project and suitable to answer our research question.

IV. Model Validation

A. Structure Validation

1. Dimensional Consistency

Vensim®DSS is capable of reporting errors in case of inconsistency of units. The model has no errors in this regard.

2. Boundary Adequacy

We suggest that the Sustainability Fund can get negative values above the Credit Line. How do the payments affect credit history of the owner and the Credit Line, and does this affect the interest rate of future loans? We simply decided not to get into the banking system in such detail and keep it simple at assigning a constant value to the Credit Line variable.

We have created seven Leverage loans, and each of these loans can have different parameters. The first one might affect the second one in terms of interest rate. However, we decided to keep the interest rate constant and again not deal with banking formulas.

3. Physical and Decision Making Constraints

The main constraint is that none of the monetary values can be negative. Loans, paybacks, and Sustainability Fund values will be meaningless if they are less than zero. However, we are allowing sustainability fund to be negative until it is more that Credit Line, meaning that bank tolerate small debts if the customer has a good credit.

Most of the variables we have added to the model are supported by simple banking logics that deal with calculations, which are self-valid.

B. Behavior Validation

1. Extreme Conditions

Two extreme conditions are considered for this part: (1) No start-up loan is available (2) A very big loan (more than what required) with low-interest rate is available. For the second case, \$50M with APR 0.1% is considered.

When we do not have any loan available, it means that we cannot improve any building so the Sustainability Fund will remain zero. This is what the model reflects and what we expect in the real world. Fig. 7 presents the behavior of the Sustainability Fund in this case. Fig. 8 presents the Sustainability Fund behavior in the second scenario. When a big startup loan with very low (almost zero) interest rate is available, it is expected that all buildings are improved, and the majority of the money will remain in the Sustainability Fund to be used for annual payments. Negative values are not expected in that the loan has no interest rate. As shown in Fig. 8, all 17 buildings get improved in the first year. In this case, the most influential factor on the sustainability fund is the loan repayment amounts that should be paid in 10 years on the yearly basis. The portion of saving from energy efficiency comparing to loan repayment values is negligible therefore the startup loan is repaid from its surplus in the Sustainability Fund so that in the month 200, only 10.1 M saving exist in the Sustainability Fund Stock.

2. Reproduction of Original Model Results

The structure of the basic model is validated by the developers. The main conceptual difference between the new and the original models concerns Leverage Loans. Therefore, in cases the project does not require Leverage Loans the new model is supposed to produce the same results as the original model. Figs. 9 and 10 show the behavior of Sustainability Fund in the original model and the new model when the order of building improvement is according to the contract.

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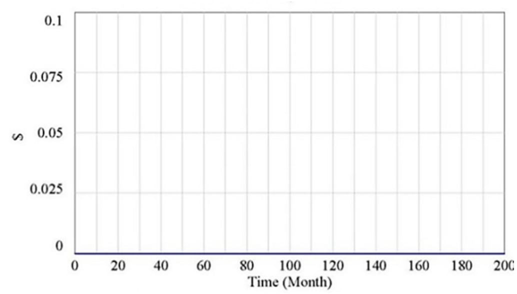

Fig. 7 Sustainability Fund in extreme condition (no loan available)

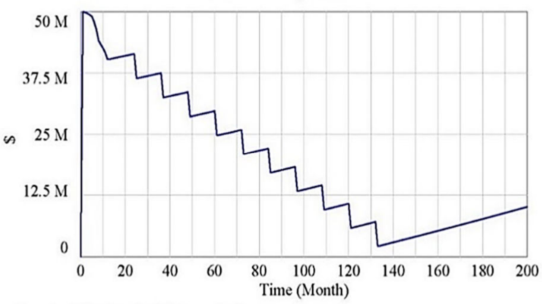

Fig. 8 Sustainability Fund in the extreme condition (a huge fund is available) (50M; APR 0%)

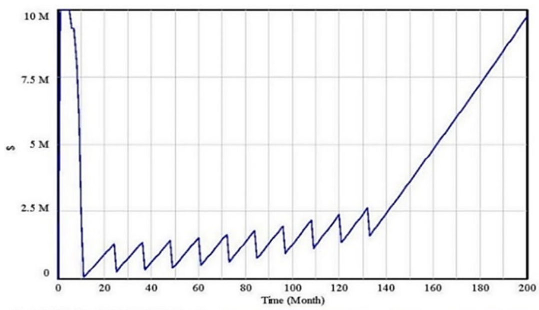

Fig. 9 The output of the original model for Sustainability Fund under the contract conditions (10M; APR 2%)

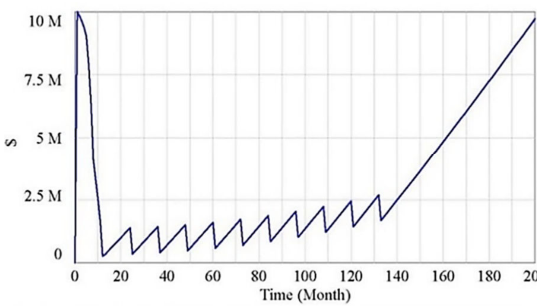

Fig. 10 The output of the new model for Sustainability Fund under the contract conditions (10M; APR 2%)

As can be seen in Fig. 10 when a startup loan with the amount of \$10M with APR 2% is available, no Leverage Loan is used, and the new model has similar behavior to the original model. In both models, all 17 buildings improved within the first year and the Sustainability Fund has the value of \$9.73M in the month 200.

V. Model Analysis

With respect to the focusing question of this research, Statistical Analysis was implemented on the model variables related to the “loan(s) conditions”. Loans are usually distinguished by (1) Interest Rate (APR), (2) Payback Period, (3) Amount. The variables representing *Interest Rate* and *Amount*, both for the start-up loan (known as Fund A in the model) and the Leverage loans (known as Fund B, C, D, etc. in the model) were picked for this purpose. The payback period was not selected because loans usually do not have a continuous range of payback period, and their payback period is usually limited to 3, 5 or 10 years. “Credit Line” variable has also been considered in the Statistical Screening analysis.

The following table demonstrates the exogenous variables along with their range and distribution used in statistical screening analysis:

TABLE I
Exogenous Variables along with Their Range and Distribution

Exogenous variable	Range	Distribution
Start-up Loan Amount (Fund A)	[5e+06,10e+06]	Uniform
Start-up Loan Interest Rate (Fund A)	[0.02,0.07]	Uniform
Leverage Loan Amount (Fund B, C, D, etc.)	[5e+05,25e+05]	Uniform
Leverage Loan Interest Rate (Fund B, C, D,	[0.10,0.16]	Uniform
Credit Line	[-400,000, 0]	Uniform

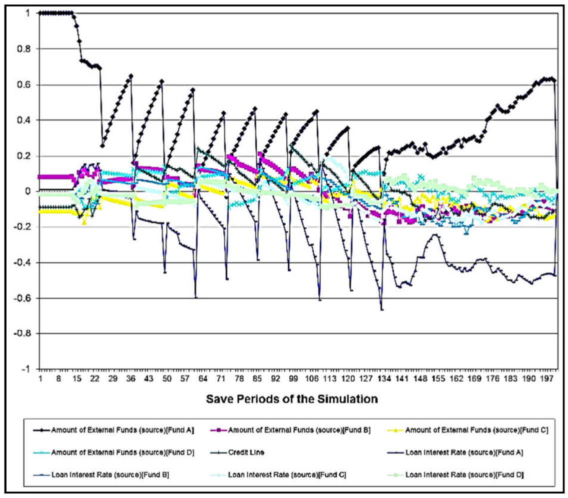

Fig. 11 Statistical Analysis Results

The variable ranges have been selected such that they represent probable conditions. For example, the start-up loan can vary from \$5M to \$10M. The maximum limit is the whole money required to improve all buildings at once. Kim et al. [1] showed start-up fund of \$5M may not result in improving all buildings within 200 months, so this value selected as the minimum. More explanation about selected range for these variables will be provided in the next section. An important point in selecting the range is that the project should not fail within these ranges, so that the Sustainability Fund value will be reliable [1].

As Fig. 11 depicts, Amount of the start-up loan (Amount of Fund A), and its Interest Rate (APR of Fund A) are the most influential factors with positive and negative correlations respectively.

The sudden changes in values of correlation coefficient concern the annual payment times of the start-up loan. In these times, the value of sustainability fund dramatically decreases due to loan payment and is less sensible to those variables. A closer look at the rest of variables as shown in Fig. 12 also reveals that Amount of Leverage Loan has positive correlation with the Sustainability Fund in the first half the period and negative correlation with the Sustainability Fund in the second half the period. This implies the dominance of the B2 loop (see the blue section of causal loop diagram – Fig. 5) early in the project and dominance of the R2 loop late in the project. As explained the payments of the start-up loan cause a distortion in correlation coefficient graphs, but it is also clear that after finishing the start-up loan payback period in month 132, the three variable of Leverage Loan Amount, Leverage Loan Interest Rate and Credit Line have negative correlation with the Sustainability Fund implying the dominance of R2 loop late in the project. The negative correlation of Credit Line suggests that, as the Credit Line decreases (e.g. from $-200,000 to $-500,000) the Sustainability Fund increases.

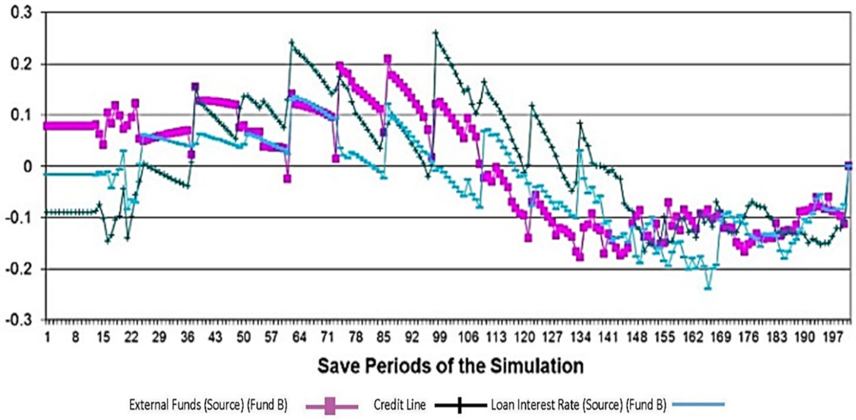

Fig. 12 Closer look at correlation coefficients

VI. Model Use

The following steps were devised to use the improved model in answering the focusing question of this research concerning the importance of the influential variables on the Sustainability Fund. Recall that the most influential variables are Interest Rate and Amount of the start-up loan.

Since the interest rate (APR) of the start-up loan is one of the most influential factors on the Sustainability Fund, the behavior of Sustainability Fund under different interest rates is simulated. At this step, it is assumed that the whole $10M required for the project is available. This step represents conditions in which the project owner (say president of a private university or facility manager of private entity) negotiates with some banks and the best interest rate offered to him is more than the attractive rate of 2% per year. In this condition some questions may cross the owner's mind which will be answered using the model:

- How much will be the value of the Sustainability Fund (total savings at the end of the program period) under this offered interest rate (APR)?
- Are another loans required (Leverage Loan) to leverage the project under this APR during the program period? And what is the impact of leverage loans on the final savings?
- What is the best order of building improvement if the leverage loan is used? Is the solution recommended by Kim et al. [1] (descending order of saving) still valid under this new condition?

The new expanded model can answer these questions. To do this, the model is run with different APR of start-up loan, and behavior modes and values of the Sustainability Fund are monitored. An APR range of 2% to 8% is considered for this step. Conventional loans APR is the function of economic conditions and dependent on various factors including market demand and the inflation rate. For economic conditions of the U.S. in the past few years, this range seems sensible. In all the analysis, including other steps, the payback period of the start-up loan is 10 years (real case of TAMU project) and of the Leverage Loans are five years (assumed). Besides, Leverage Loans are assumed to have a constant APR of 13% (this value does not change during the analysis). This is close to Credit Cards interest rate, which is always available for money seekers. Leverage Loans should have more interest rates than the start-up loan because otherwise they would be used as the start-up. Another reason is that they usually should be acquired fast when needed. The amount of Leverage Loans will be discussed later. Other data used in the model analysis are the same as the original model. The analysis period is also 200 months.

The amount of the start-up loan is another highly influential factor on the Sustainability Fund. The performance of the Sustainability Fund when only a portion of the required fund is available will be investigated using the model in this step. Assume the facility manager mentioned above, not only cannot find a loan with 2% APR but also there is a limitation on the amount of money he can borrow. In this case his questions would be:

- How much will the value of the Sustainability Fund be under the limitation of the available loan and the offered interest rate (APR)?
- Will be required to get another loan(s) during the program period (Leverage Loan) to leverage the project under these new conditions and what are their impacts on the final savings?
- If the entire required fund is not available at once, will all the buildings be improved finally?
- What is the best order of building improvement if this loan (s) is used?

In this step, the model is run with different APR and amount of start-up loan (both vary). The behavior modes and values of the Sustainability Fund are monitored to answer these questions.

The simulations discussed in the two previous steps are done using the minimum guaranteed savings indicated in the TAMU contract. However, the actual performance of the Sustainability Fund and real amount of savings due to the Energy Efficiency measures is of great importance. The actual energy consumption data can reveal how better or worse is the project compared to the expectations (i.e. guaranteed values). In this step the actual energy consumption data for the project buildings after improvement (the fiscal year 2012 and 2013) will be compared to the guaranteed values, and behavior modes and values of the sustainability fund will be investigated under different conditions of Interest Rate and Amount of available start-up loan.

VII. Results

A. Step 1

In this step, the model was run with $10M start-up loan and different APR from 2% to 8%. Results are categorized based on three different ordering policies proposed by Kim et al. [1]. As it was predictable that the model would use Leverage Loan in some simulations, an assumed value of $1 million was set for Leverage Loans in the first try. This suggests every time that the Sustainability Fund goes below the Credit Line; owners borrow a $1M loan to leverage the project. A sample of the behavior model graphs produced by the model is presented in Fig. 13.

To clarify how the behavior modes show the use of Leverage Loans and their impact on the Sustainability Fund. As one can be seen in Fig. 9, the Sustainability Fund in some points (at different times for different ordering policies) goes below the Credit Line. These large debts happen because the savings from conserving energy is less than the loan payments. Once this happens, a Leverage Loan is added to the Sustainability Fund resulting in a sudden jump in its value. In fact, the Leverage Loan helps the program to survive. But after using any Leverage Loan, its monthly payments are added to the project payments resulting in different slopes in the graphs. After finishing the annual payments of the start-up loan, payments of the Leverage Loans still exist which are deducted monthly from the Sustainability Fund. This results in the curve shape of the graph after the saw-tooth part. The big gap at the end of the time period between the green line (representing ascending order of cost) and the two other lines is due to the fact that by improving buildings in “ascending order of cost” four Leverage Loans are used while the other policies use only two Leverage Loans.

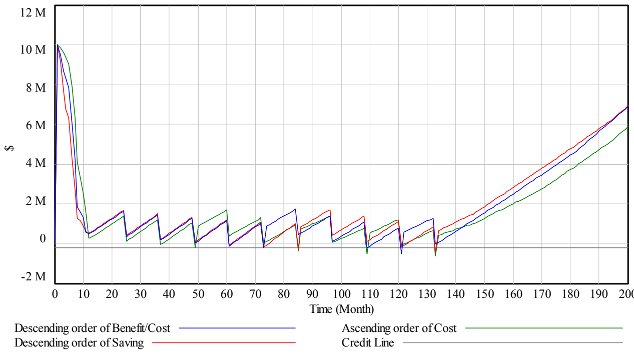

Fig. 13 Sample Simulation Result ($10M Start-up; APR6%)

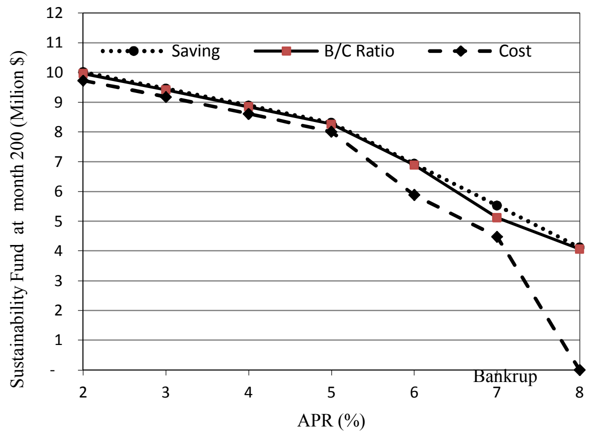

Fig. 14 Sustainability Fund with different APR of start-up loan ($10 M) and effect of using Leverage Loans ($1 M)

The results of all simulations run in the first try of this step are summarized in Fig. 14. Results revealed that if the project APR is less than or equal to 5% the project will not need Leverage Loan. However, at APR 6%, 7%, and 8% the project’s success depends on the availability of the Leverage Loans (Leverage Loans will be used in the project). The sudden change in the slope of the graphs in Fig. 14 shows the impact of Leverage Loan payments on the Sustainability Fund. In fact, the Sustainability Fund decreases more sharply after APR 6% than before.

The word "Bankrupt" on the graph indicates that the used Leverage Loan was not sufficient to compensate the project debt. As stated before, it was the first try assuming a set of

$1M Leverage Loan. This encourages figuring out the optimum value for Leverage Loan such that not only it is sufficient to compensate the project debt, but also results in the highest Sustainability Fund. Regarding the fact that bigger loans will have larger paybacks, this optimum should be the minimum amount of loan that can compensate for the project debt. To do this, it is assumed that the Leverage Loan can be got in five discrete values: $500,000 - $1M - $1,500,000 - $2M - $2,500,000. Please note that borrowing as much as the current debt is not a wise policy. The reason is that the project debt happens due to small savings and large payments, which will continue for the rest of the project period. If the Leverage Loan is not more than the debt, a worse debt will happen at the time of next payment. In this regard, the Leverage Loan should be more than the debt. Fig. 15 summarizes the final results of this step using the optimum amount of Leverage Loan.

When the whole $10M required fund is available, the Sustainability Fund (the final savings of the project at month 200) decreases as the APR increases (an expected result). Its value changes almost linearly from 2% to 5% where no Leverage Loan is required. After that, its value decreases more than before which is the result of Leverage Loan payment. Leverage Loan is inevitable at 6%, 7%, and 8% APR. The value of the sustainability fund at each APR, the optimum amount of each Leverage Loan, and behavior of the final savings versus APR are demonstrated in Fig 15. Based on the results of this step, if the entire fund is available the best strategy is always to improve buildings in descending order of saving regardless of the APR. This is same as the result obtained by Kim et al. [1] for a special case of Apr 2%. Also, the importance of the ordering strategy increases as the APR increase. The increasing gap between the green line and the blue ones implies improving buildings in ascending order of cost will result in large loss of potential savings at high-interest rates.

B. Step 2

In this step, the model was run with the different amount of start-up loan at different APR of 2%, 4%, 6% and 8%. For each combination of amount and APR the optimum Leverage Loan was used in simulations (found by the process described in the previous step). Results are categorized based on three different ordering policies for improvement proposed by Kim et al. [1] including descending order of saving, descending order of B/C ratio and ascending order of cost. The following graphs shown in Figs 16-19 illustrate the results of this analysis. As was expected, in some scenarios the available fund is not enough to improve all buildings. Negative numbers on some points indicate the number of buildings that could not be improved.

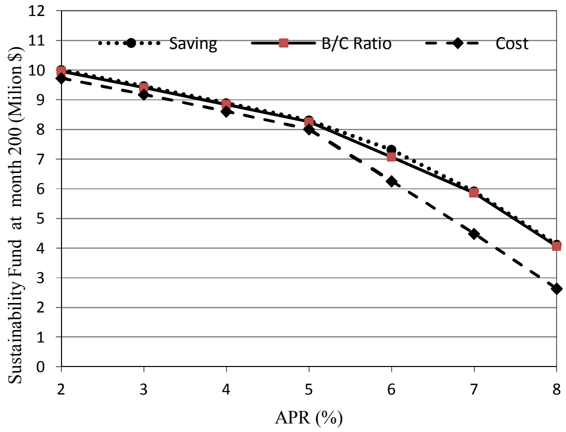

Fig. 15 Analysis results, step 1 ($10M start up – optimum Leverage Loan)

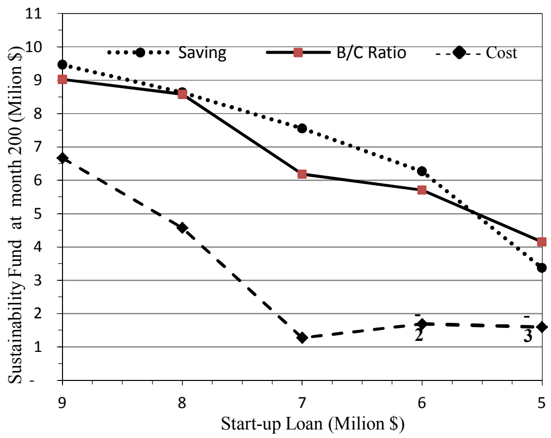

Fig. 16 Analysis results, Step 2; APR 2%

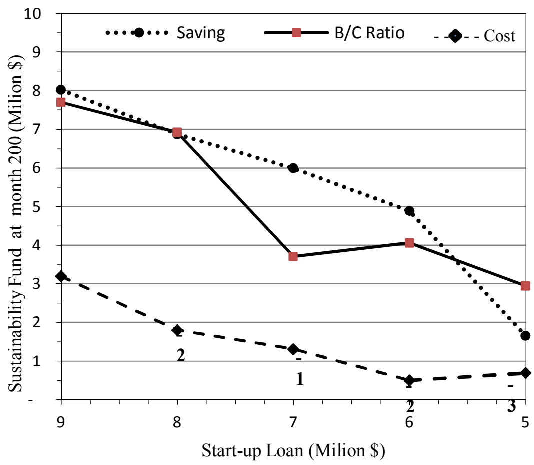

Fig. 17 Analysis results, Step 2; APR 4%

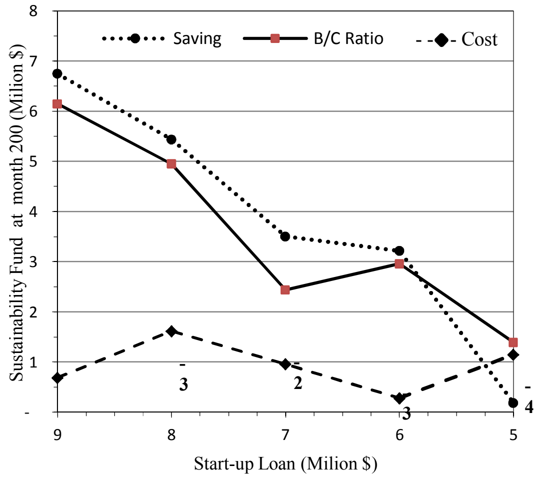

Fig. 18 Analysis results, Step 2; APR 6%

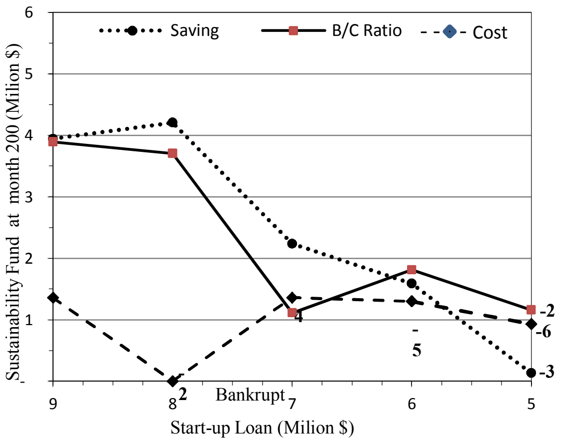

Fig. 19 Analysis results, Step 2; APR 8%

The most interesting result of this analysis is that as the available fund decreases and APR increases the best policy of building improvement changes. As Fig. 16 shows at all APRs if the available loan is $5M the best policy is to improve buildings in "descending order of B/C ratio". This is same as the result obtained by Kim et al. [1] in the special case of APR 2% and $5M start-up loan. Besides, lack of initial funding in some cases prevents some buildings to be improved. Even with 2% interest rate, $5M start-up loan is not strong enough for improving all buildings if the buildings are improved in ascending order of cost. And, with APR 8% and the same ordering policy there is no way to improve all buildings if the entire $10M is not available. The following table summarizes the effect of different combinations of APR and start-up loan on the Sustainability Fund (total savings at month 200) and the best ordering policies.

C. Step 3

Using the available data of the buildings energy usage in the past two years (FY 2012 and FY 2013), a comparison between the guaranteed and actual energy savings conducted. Results show that the actual energy conservation due to building improvement is much higher than the expectations (guaranteed amounts). Calculation shows that on average actual energy consumption per month in forms of electricity, chilled water, and hot water is 74%, 77%, and 92% of the guaranteed (predicted) values respectively. The actual energy consumption data was used in the model to investigate the effects of start-up loan amount and APR on the Sustainability Fund under more realistic conditions. Analysis of this part is based on "building improvement in descending order of saving" if the entire fund is available, and "descending order of B/C ratio" if just $5M start-up loan is available. These are known best policies based on the results of previous parts. The following graphs summarize results of this analysis.

Integrating the actual data into the model produces impressive amounts of savings. Under the TAMU contract conditions, the project will result in savings about $37.8M after 200 months. It is much more than the expectations and guaranteed values before starting the project. When the entire required fund is available ($10M) the project will not need any Leverage Loan if the start-up loan APR is less than or equal to 28%. At APR 29% the project faces problem for the loan payments three times and needs Leverage Loan to survive. The actual consumption data revealed that the project has a great margin of financial safety.

If only the half of the required Fund is available (i.e. $5M), the project is still capable of providing huge savings for the owner. Obviously, the best results are obtained when the lowest APR applies to the start-up loan. In case of APR 2%, the project will result in about $33.3M savings and the last building is improved in month 65. The project will not need Leverage Loan unless the APR exceeds 30% (APR 31% is the first time that the project uses Leverage Loan twice).

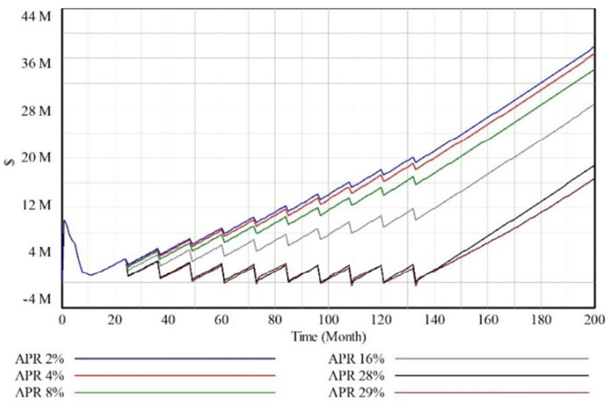

Fig. 20 Sustainability Fund behavior using actual energy consumption with start-up loan of $10M (biggest saving first)

TABLE II
THE EFFECT OF DIFFERENT COMBINATIONS OF APR AND START-UP LOAN ON THE SUSTAINABILITY FUND

Best Policies & Final Savings			Start-up Fund (million $)					
			$10M	$9M	$8M	$7M	$6M	$5M
Loan APR	8%	Best Improvement Order	Saving	Saving	Saving	Saving	B/C	B/C
		Sustainability Fund (million $)	4.12	3.94	4.21	2.24	1.81	1.16
		# of unimproved buildings	-	-	-	-	-	2
	6%	Best Improvement Order	Saving	Saving	Saving	Saving	Saving	B/C
		Sustainability Fund (million $)	7.31	6.75	5.43	3.50	3.22	1.39
		# of unimproved buildings	-	-	-	-	-	-
	4%	Best Improvement Order	Saving	Saving	Saving	Saving	Saving	B/C
		Sustainability Fund (million $)	8.89	8.02	6.87	5.99	4.89	2.95
		# of unimproved buildings	-	-	-	-	-	-
	2%	Best Improvement Order	Saving	Saving	Saving	Saving	Saving	B/C
		Sustainability Fund (million $)	10.01	9.46	8.63	7.55	6.26	4.15
		# of unimproved buildings	-	-	-	-	-	-

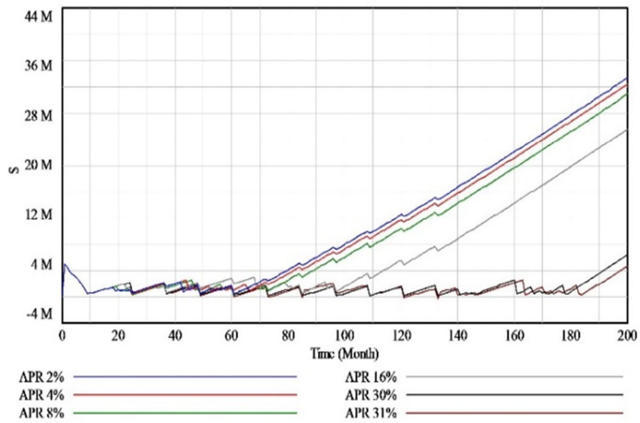

Fig. 21 Sustainability Fund behavior using actual energy consumption with start-up loan of $10M (biggest R/C ratio first)

Another interesting result of the analysis is that even with only $1M at APR 2% (which is only sufficient to improve the first building) all buildings can be improved within 150 months, and the project can provide savings as big as $14.3M.

VIII. CONCLUSION

The current work has tried to improve the research done by Kim et al. [1]. The original System Dynamics model of the TAMU Sustainability Fund project presented in their work was expanded to include more realistic conditions. The concept of Leverage Loans had been added to the model before it was used to answer the research question. This study was intended to clarify the behavior of the Sustainability Fund and financial consequences of different financing options (different APRs and amount of the start-up loan) in the initiation of such sustainability project. Also, the data of actual energy consumption after implementing TAMU sustainability project was used to investigate how better or worse than the predictions the project performs.

Results of this work showed that for APRs more than 5% ($10M start-up loan of the TAMU project) and savings as small as the guaranteed amount, the project would need Leverage Loan. Payments of the Leverage Loan would result in the considerable decline in the final savings. For the whole range of investigated interest rates (2% to 8%) the best policy when the entire fund is available is to improve buildings in descending order of saving. As the loan APR increases choosing the correct ordering policy has a bigger effect on the final savings. The best ordering policy also depends on the amount of available start-up loan. As the amount of start-up loan decreases, the best policy changes from the "biggest saving first" to the "biggest B/C ratio first". Integrating the actual energy consumption of the TAMU project revealed that such projects have very good financial margins. Such a safe financial conditions is a big incentive for the owners to initiate similar sustainability programs in their facilities.

The main contribution of this work in the context of System Dynamics is to introduce the feedback loops included in the structure of leveraging the project that are about to fail. In the context of project management, this study more realistically clarifies the financial aspects of energy efficiency project with Paid-From-Saving concept. However, there the main weak point of this research to this end is that it does not consider the degradation and deterioration of the Energy Efficiency tools used to improve buildings (such as sensors, etc.). It is sensible to believe that the final savings of the project would be less than the values presented by the current model because degradation of those tools would decrease the amount of energy savings. The same applies to the aging of the buildings. In this regard and interesting idea to develop the current work would be to include the aging process of both the energy efficiency tools and building into the model.

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