Managing risks in complex building retrofitting projects for energy and water efficiency

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Presentation outlines

1. Introduction
2. Aims and objectives
3. Review of risks in building retrofitting project
4. Proposed risk management framework
5. Future work
Introduction: The Needs

1. Globally the building sector accounts for:
   1. 40% energy consumption
   2. 25% water consumptions,
   3. 30% CO2 emissions.

2. Energy efficiency of buildings is a key component of reducing energy and water use and achieving the emission reduction target set by international protocols.

3. The market for green retrofitting is growing worldwide
   1. $80.3 billion US dollar in 2011
   2. $151.8 billion by 2020.
   3. In U.S., market for green renovation was $2.1 billion/year in 2009, and grew over $6 billion a year by 2013.

4. In Melbourne in last 5 years, 37% of commercial buildings were retrofitted:
   1. average cost of retrofitting ($343,000/building) and
   2. 12% of those over $1 million/building.
Introduction: The Risks

1. A comprehensive building retrofitting may cost up to hundreds of millions of dollars.
2. Due to the large investments, proper design and planning of building retrofitting process are important to ensure targeted environmental and financial benefits are achieved.
3. unique constraints in building retrofitting projects:
   1. financial constraint,
   2. work hour constraint,
   3. workspace constraint,
   4. material and equipment transportation,
   5. surrounding environment,
   6. technology and equipment,
   7. policy and regulation
4. There are unique risks and risk criticalities to building energy retrofitting project design and management. These associated risks should be identified, analysed and managed.
5. A comprehensive risk management framework is essential.
Research Aims and Objectives

- The overall aim is to develop a life-cycle risk management framework.

- Specific objectives are:
  
  1. *Conduct a literature review to identify the associated risks, risks evaluation and risk mitigation measures in a building retrofitting project.*


AS/NZS ISO 31000:2009 for risk management

Communication and Consultation

Establishing the context

Risk assessment

Risk identification

Risk analysis

Risk evaluation

Risk treatment

Monitoring and Review
Risk factors in building retrofit project

- **Financial Risk**
  - Design, construction, certification and maintenance of energy/water efficient buildings is too costly for some companies.
  - Loss of possible financial gain if the building doesn’t perform as it was intended to during design stage.
  - Lack of accurate prediction of return on investment.

- **Market Risk**
  - Lack of knowledge in financial institutions in regards to green buildings, results lending based on the status quo.
  - Real estate agents are unable to articulate the benefits of green building.
  - Misconceptions about green buildings’ energy efficiency.

- **Economic Risk**
  - Commodity price volatility such as increase in labour cost, material cost, equipment costs, electricity price, oil price etc. will reduce the profit margin from an energy efficiency project.
  - Interest rate volatility in loan market will increase financing cost.
Risk factors in building retrofit project

- **Legislative Risk**
  - Tax and regulatory incentives are not uniform and tend to change from state to state, and over time
  - As legislation changes, risks are introduced that are not yet known and cannot be controlled by decision maker
  - Uncertain expiration dates on incentives

- **Social Risk**
  - Retrofit is usually performed while existing operations are still running, thus causing substantial disturbance to tenants. Some tenants are uncooperative for fear of losing income during the retrofit process.
  - To maintain the benefits after the retrofit, equipment has to operate at its best efficiency, which requires tenants’ continuous cooperation.

- **Project Design Risk**
  - May result from the lack of sufficient and inaccurate information of the building system.
  - Inaccurate prediction of baseline and energy/water savings.
  - Inexperienced and uncooperative team members could result in difficulty in obtaining certification, delays, and budget overruns.
Risk factors in building retrofit project

➢ Industry Risk
  • Lack of relevant knowledge regarding building retrofitting project among the involved parties.
  • The green building demand may not be satisfied by the supply chain e.g. recycled materials etc.
  • Skilled workers may not be available to handle the specialized design and features in the green retrofitting process.

➢ Technological Risk
  • Unstable/poor performance of the retrofitted technologies /materials /equipment
  • In case of improper equipment sizing, equipment frequently operates at part-load condition which results in reduction of energy/water savings.

➢ Installation Risk
  • Delay in project completion due to a number factors. This results in an increase in project cost and delay in commencement of energy/water savings.
  • Installation of the retrofit measures may not be done properly which results in risks of not achieving the desired energy/water savings.
Risk factors in building retrofit project

- **Operational Risk**
  - Faster rate of equipment degradation due to poor maintenance.
  - The retrofitted equipment is not being operated at optimum condition to maximise energy/water savings.
  - Unexpected consumption patterns. Changes in baseline condition such as weather, operating hours, load requirement etc.

- **Measurement and Verification Risk**
  - Poor quality of the measured data. For example, low-resolution data or missing data. This increases the uncertainty on energy/water savings measurement.
  - Establishing improper measurement and verification plan for the retrofitted building which may result in dispute over actual savings.
  - Measurement error due to the use of inaccurate metering device
Risk Analysis and Evaluation

- Provides an understanding about the magnitude of each identified retrofitting risk and the need for risk treatment based on the risk criteria
Qualitative Risk Analysis Method

- Depends on expert knowledge and experience in assessing the significance of the identified risks.

- Prioritizes the identified risks factors using a pre-defined rating scale.

- A widely used formula to qualitatively calculate risk is below with predefined rating scales

\[ \text{Risk Significance} = \text{Probability} \times \text{Impact} \]

- In this assessment method, a survey questionnaire is distributed to the respondents to indicate the probability and impact of each identified risk factors via a five-point Likert scale where 1 denotes “least important” and 5 denotes “most important”

- To ensure the quality of the risk assessment, the survey respondents should be selected carefully based on their knowledge and experience
Quantitative Risk Analysis Methods

- Quantitative risk analyses process uses simulation tools and statistical analysis to quantify the magnitude of risks and its impact on the project objectives.

- It is generally more time consuming and needs high-quality data but is very useful for more detail analysis of highest priority risks in a project.

- Quantitative assessment process of building energy savings uncertainty risk consists of the following steps:

  *Step 1 Baseline model calibration*
  *Step 2 Techno-economic analysis of retrofit measures considering risk*
Baseline model calibration

- Calibration of the building energy model is essential for reliable estimation of energy benefits.
- Among the available calibration approach, Bayesian approach is preferred by the researchers for this purpose.

*Figure: Bayesian calibration process (Yeonsook Heo et al. 2013)*
Techno-economic analysis of retrofit measures considering risk

Source: Sun et al. 2016
Risk Treatment

1. Risk treatment is an action or a series of actions designed to deal with the presence of risk. If the level of a building retrofitting project risk is beyond the limit set in risk criteria, it needs to be reduced using existing knowledge and capability.

2. Risk Mitigation measures for can be defined through consultation with the stakeholders, experienced professionals and reviews of previous studies. A Likert scale can also be used to identify the most significant risk mitigation measures.

3. In the case of quantitative treatment, use of appropriate simulation model input parameters during design stage can also reduce the gap between simulated and actual energy savings and hence, reduce the risk of energy/water savings uncertainty. (???)

4. Selection of the most appropriate risk treatment option requires a balance between costs and efforts of implementation and the potential benefits
Risk management framework for building retrofit project

1. Establish the context of energy retrofitting project
2. Identification the potential retrofitting risks and their sources
   - Qualitative: Likelihood, Impact
   - Quantitative: Bayesian calibration, Monte Carlo simulation
3. Analysis of the identified retrofitting risks
4. Determine level of identified risks
5. Communication and consultation with key stakeholders (owner, investor, designer, consultants, contractors, suppliers, and tenants)
6. Evaluation of risks
   - Compare against defined risk criteria
7. Identification of retrofitting risks mitigation measures
8. Preparation and implementation of the risk mitigation plan

Monitor and review

Retrofitting risks database for Design, construction and operation stage
Retrofitting risks mitigation measures database Design, construction and operation stage
Future Work

Database for identifying retrofitting risks and mitigation measures

1. A database of risks and mitigation measures in building energy/water retrofitting project.

2. Database will be developed by storing the knowledge and information gained from past retrofitting projects regarding risks and mitigation measures. The database will also include results of a large number of building energy/water retrofitting simulations.

3. The simulations will be carried out using several prototypic buildings that represent entire building stock of a climate zone and different retrofitting scenarios.

4. For a particular building type and selected retrofitted options, the database can provide information about the possible associated risks and risk mitigations measures.
Conclusions

1. building energy/water retrofitting project is associated with many risks during design, construction and operation stage and requires proper risk management.

2. A life-cycle risk management framework has been developed, which is based on the AS/NZS ISO31000:2009 standard risk management framework.

3. The proposed risk management frameworks is interactive within and between the design, construction and operation stages.


5. Development of a risk database is expected to be helpful in developing an effective risk management.
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Call for contribution and participation

- We are looking for retrofitting project to conduct case study
- We welcome your comments, contribution and participation in this project.
- Thank you!

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