The various facets of risk -

Proposed WtE project in Iceland

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Aim of case study

Analyze and review the various facets of risk in a proposed Waste-to-Energy project in Iceland:

- Compliance with governmental sustainability goals
- Strengthen the circular economy

Preparation of risk analysis

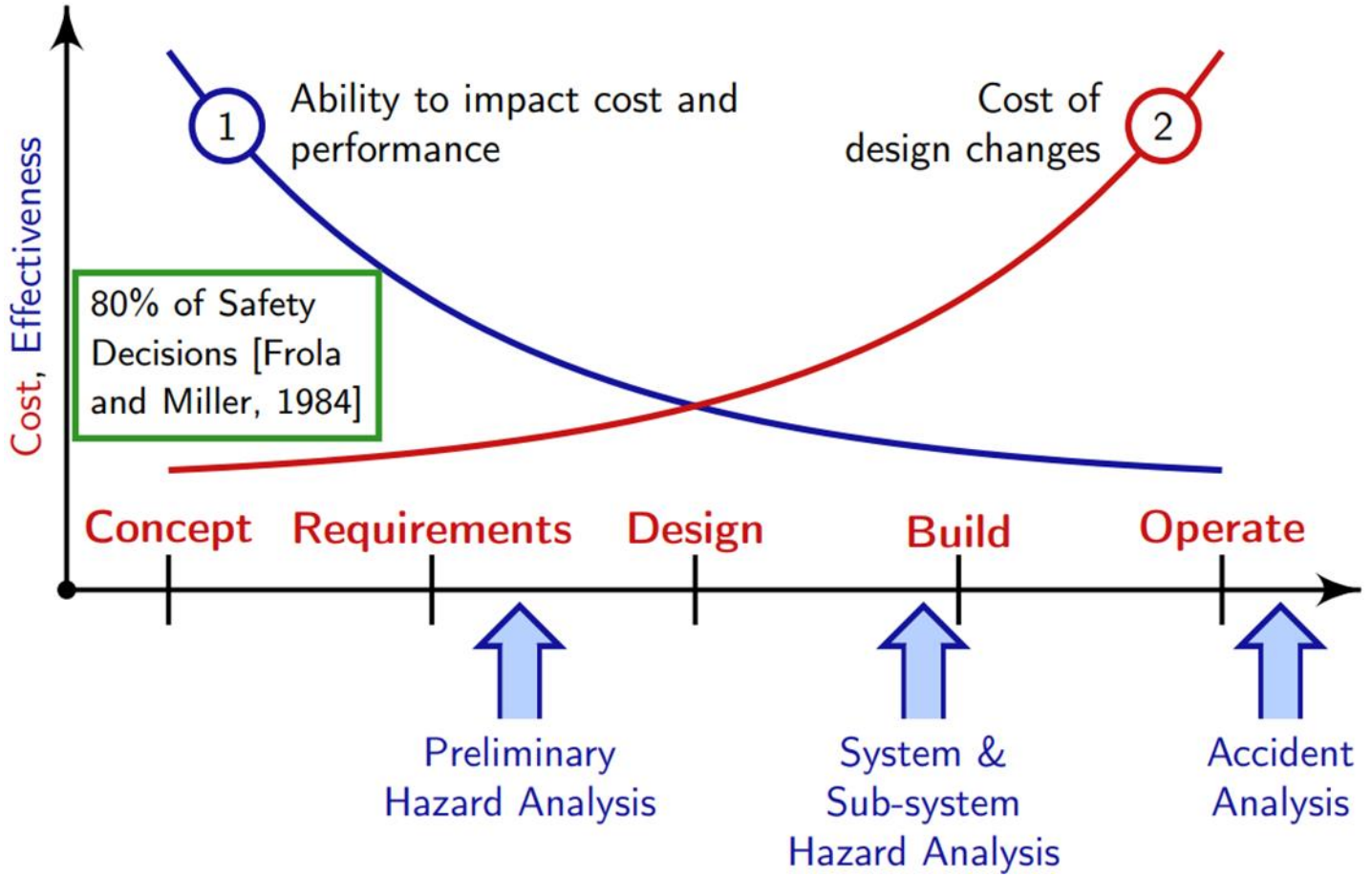
- Review of …
  - Recent scientific articles
  - Reports from other experts in the preliminary project in 2021 reg. risk factors
  - Meeting minutes from the preliminary project steering group
  - Laws and regulations

- Choose three different methods/techniques to analyze risk

Context

- Due to the increased focus on the circular economy within Europe, the disposal of combustible waste by landfilling will be stopped.
- The Paris Agreement 2016 – International treaty to reduce the effects climate change.
- Now, a stronger emphasis is placed on the sorting of waste, and to use incineration for energy production instead of landfilling.
- It is estimated that by 2030 up to 130,000 tonnes of combustible waste will be generated in Iceland per year.
- Feasibility study was conducted to examine what kind of incineration plant could be built to incinerate this material and deliver 10 MW of energy and 28 MW in the form of heat.

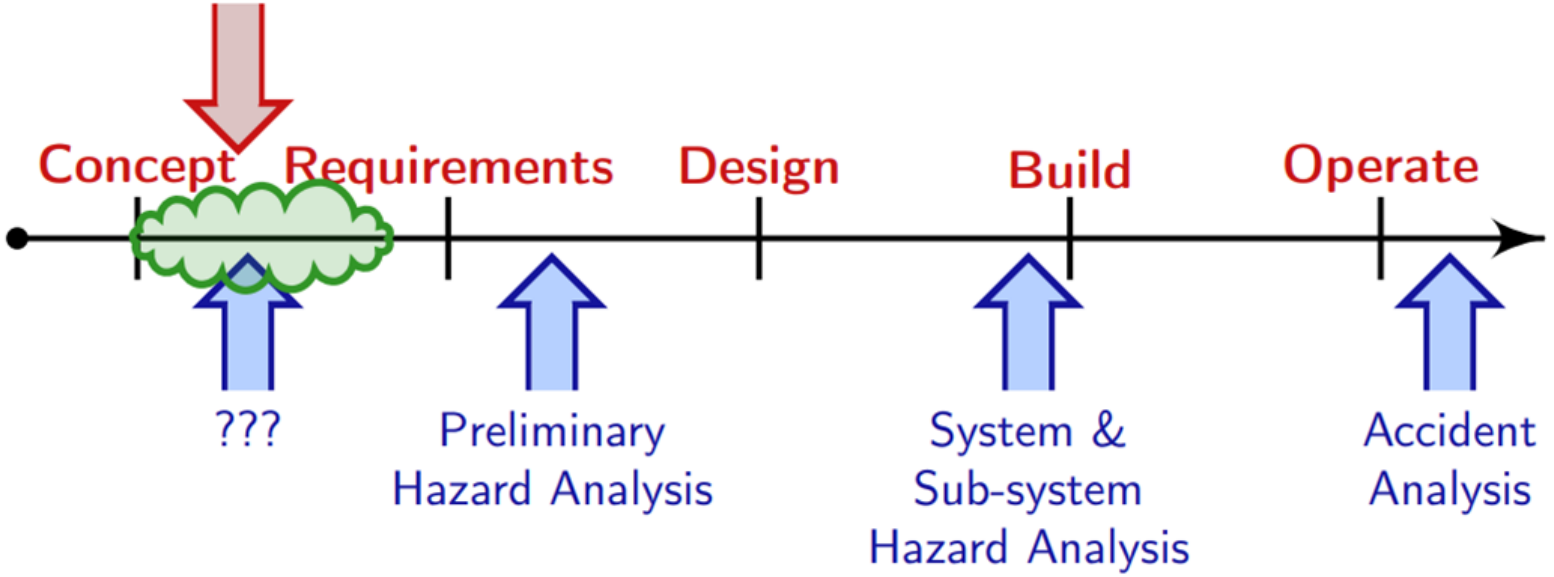
Why start early with the risk analysis?



A clear incentive to address risk early

A challenge at the beginning

- limited design information
- no specification
- informal documentation
- concept of operations ≡ "ConOps"

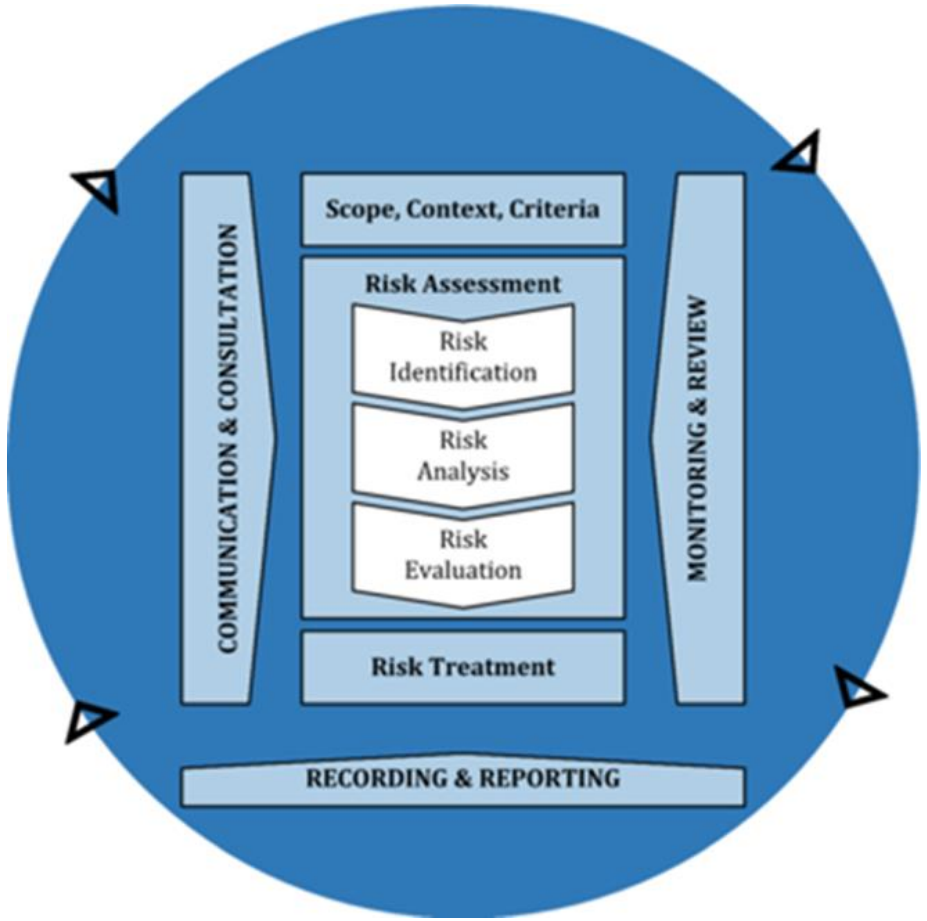


A common problem in larger projects

A case study conducted

1. Review recent literature on WtE projects
2. Apply three different risk analysis techniques based on ISO 31000:2018, *Risk management – Guidelines*:
   a) PMI (Project Management Institute)
   b) VUCA (Volatility, Uncertainty, Complexity, and Ambiguity)
   c) STAMP (Systems-Theoretic Accident Model and Processes) and STPA (Systems-Theoretic Process Analysis)

Based on ISO 31000:2018 Risk management - Guidelines



The process of risk management and risk analysis according to ISO 31000:2018

Three different risk analysis methods provide different perspectives

1. PMI method – traditional and fast:
   - Brainstorming based on severity and probability assessment
2. VUCA method – covers economic and social factors:
   - **V**olatility: things that can change quickly, usually for the worse
   - **U**ncertainty: factors that create uncertainty
   - **C**omplexity: factors that complicate the situation
   - **A**mbiguity: can have multiple meanings and interpretation possibilities due to ambiguity
3. STAMP/STPA method:
   - Systems-Theoretic approach: based on control theory, covers causality, time factors, human interaction and technology

Conducting the risk analysis

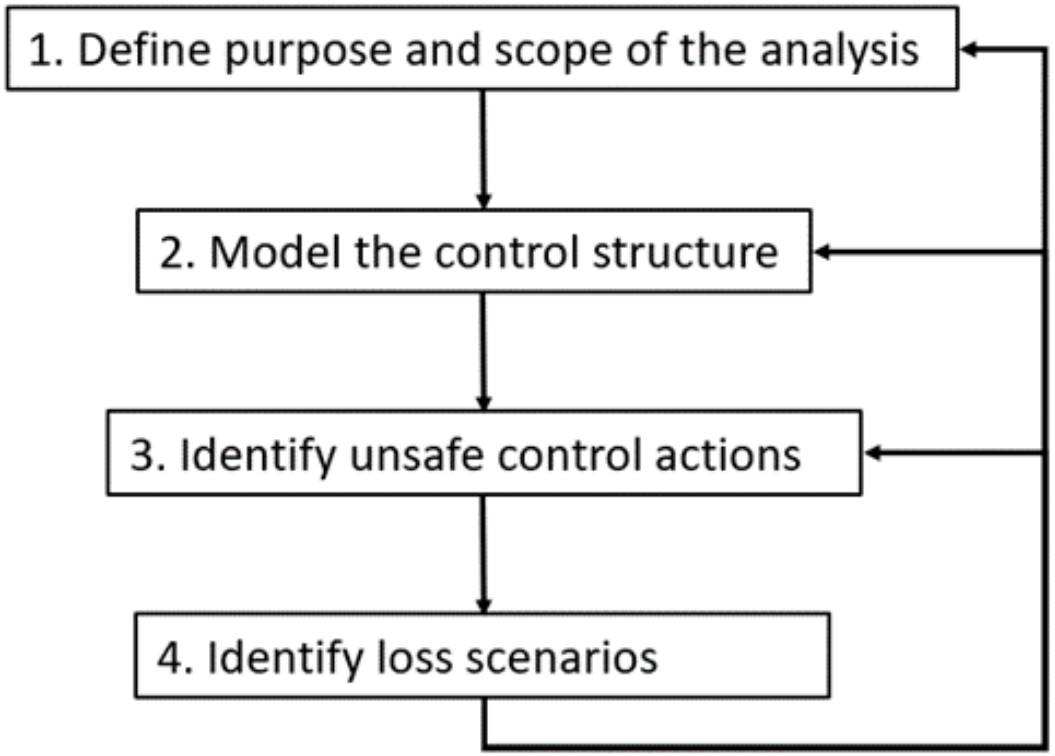
Two workshops with 18 people held at Reykjavik University in the autumn 2021

1. PMI method yielded 155 risk factors
2. The VUCA method yielded 304 risk factors, 149 more than PMI
   - The processing of VUCA analysis continues as a master's project at RU
3. A system model developed based on STAMP and risk analysed with STPA

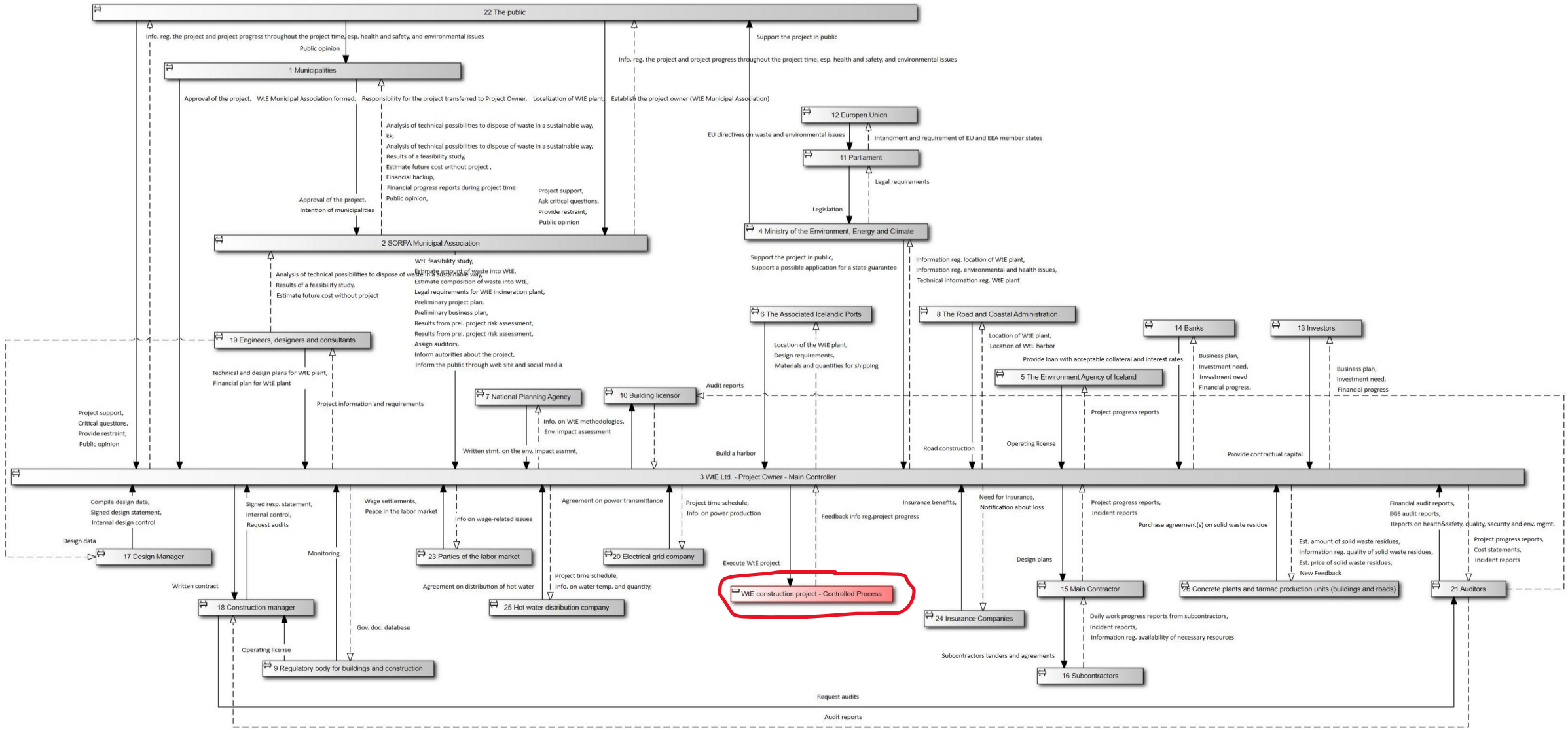
Example of PMI method results

No.	Risk factor	Likelyhood (L) 1-5	Consequences (C) 1-5	Calculated risk = L*C
1-3	Quantity of incineration plant vs. quantity of combustion waste	5	5	25
1-3	New regulations from the EU, the incinerator does not comply	5	5	25
1-3	Strike	5	5	25
4-6	The need for solution in relation to contaminated bio-waste and animal carcasses leads to the construction of many smaller incinerators in many parts of the country	5	4	20
4-6	Underestimation of waste quality	4	5	20
4-6	Changes in the amount of waste to the station	4	5	20
7-8	Protests by residents due to pollution	4	4	16
7-8	The definition of what can be burned narrows	4	4	16

STAMP/STPA conducted in 4 steps



STAMP system model for the construction phase



System model developed in STPA software module, https://www.riskmanagementstudio.com/stpa-software-solution/

26 stakeholders in the construction phase, example

WtE Inciniration Plant - PPP Project - Construction Phase					
Stakeholder in Construction Phase - No.	**Name of Stakeholder in Construction Phase**	**Responsibility**	**Feedback needed [from Stakeholder(s) No.]**	**Action [to Stakeholder(s) No.]**	**Description of Action [Control Action = CA]**
S-1	Municipalities	(a) Legal obligation to dispose of waste in a sustainable way (b) Project feasibility study (c) Project risk assessment (d) Responsibility for financing the whole project (e) Establishing the PPP partnership for the project (f) Supervisor role	(a) Analysis of technical possibilities to dispose of waste in a sustainable way [S-2, S-19] (b) Results of a feasibility study [S-2, S-19] (c) Estimate future cost without project [S-2, S-19] (d) Financial backup or guarantee [S-9, S-13, S-14] (e) Financial progress reports during project time [S-3] (f) Public opinion [S-22]	(a) Approval of the project (a subprocess) [S-3] (b) Establish WtE Ltd as a Project Owner (a subprocess) [S-3] (c) Responsibility for the project transferred to Project Owner [S-3] (d) Location decision for the WtE plant [S-3]	(a) The approval of the project is both an output of the approval subprocess that is partial prepared by S-2 (in a pre-phase of the project) and a requirement. (b) This is an output of the approval subprocess and a special establishment subprocess, but also a requirement. The WtE Ltd will be formed if and when all the main municipalities in the country are ready to unite on the project - and if Minister for the Environment and Natural Resources of Iceland supports the project - and if (potential) investors (S-11) have been found. (c) This is an output of the approval subprocess. (d) This is an an output of the approval subprocess and a requirement.
S-3	WtE Ltd - Project Owner	(a) Project owner (PPP affiliate) (b) Project management, including reg. quality, health&safety, environmental and sustainability requirements (c) Ensure project financing (d) Daily supervision during project time (e) Appoint a design manager (f) Appoint a construction manager (g) Assign auditors (h) Apply for a construction permit for the intended project and provide the necessary data, e.g. environmental assessment	(a) Results from a preliminary project plan [S-2, S-19] (b) Results from a preliminary business plan [S-2, S-19] (c) Results from a preliminary risk assessment [S-2, S-19] (d) Project progress reports [S-15] (e) Reports from auditors [S-21] (f) Public opinion [S-22]	(a) Environmental impact assessment (a subprocess) [S-10] (b) Application for WtE plant, building permit application and building documents (a subprocess) [S-10] (c) Sign contracts with clear split of responsibility [S-1, S-10, S-17, S-18, S-19, S-20, S-21] (d) Starting the project [S-10, S-15, S-22] (e) Project plan [S-10, S-15, S-17, S-18] (f) Business plan [S-10, S-15, S-17, S-18] (g) Tendering the project (main contractor) [S-15, S-16] (h) Choose main contractor and sign contract [S-15] (i) Inform the public through web site and social media [S-22] (j) Inform authorities about the project [S-4, S-5, S-7] (k) Seek/monitor public opinion [S-22] (l) Assign auditors [S-10, S-21]	(a) This is a one-time output of an environmental assessment process conducted by Project Owner and a requirement. (b) This is a one time output of the building permit application. (c) This is an output. (d) This is a one-time output. (e) This is an output from feasibility study (from S-2), reviewed by S-3 and maintained as a "live" project plan, constantly reviewed through the project time. Also a requirement. (f) This is an output from feasibility study (from S-2), reviewed by S-3 and maintained as a "live" project plan, constantly reviewed trough the project time. Also a requirement. (g) This is both a one-time output and a requirement. (h) This is both an one-time output and a requirement. (i) This is a continuous CA. (j) This is a continuous CA. (k) This is a continuous CA. (l) This is a requirement.

Examples of system losses that should not occur during the project time:

Loss ID	Name of Loss
L-1	Loss of money (costs exceed budget)
L-2	Loss of life - injuries of people
L-3	Loss of environmental quality
L-4	Loss of time/deadline
L-5	Loss of credibility - negative image

Examples of hazards/threats that can lead to a system loss during the project time:

Hazard/Threat ID	Name of Hazard/Threat	Resulting Losses
H-1	During the construction of the plant a minimun safety distance violation occurs	L-2, L-3
H-2	During the construction of the incineration plant disputes arise between parties that are not covered by contracts and cannot be resolved	L-1, L-3, L-4, L-5
H-3	During the construction phase the legal responsibilities of the stakeholders and contractors are unclear	L-1, L-4
H-4	During the construction phase the delivery of materials are delayed	L-1, L-4

Main results from risk analysis

Risk in the project phase:

1. Risk is related to the financing of the project.
2. Many risk factors are associated with site selection, e.g., negative public opinion and transport. A positive image can support the circular economy, improve public environmental awareness and strengthen people's willingness to actively participate in any kind of sustainability projects.
3. Risk factors associated with forming a suitable project owner organization.
4. Risk factors associated with the licensing process and building permit.

Main results from risk analysis

Risk in the project phase:

5. Health and safety risk of people.
6. Risk and uncertainty regarding design criteria (waste quantity and burning value).
7. Risk due to "poor" contracts and unclear risk sharing.
8. Sloppy project management creates risk, e.g. risk of accidents, project delays and increased cost.
9. Risk is associated with the failure to carry out a comprehensive risk assessment covering the preparation, design, implementation and operation of a waste incineration plant to support decisions.

Main results from risk analysis

Risk in operation:

1. Risk is related to the amount of waste and the burning value of it the material that reaches the plant, e.g. that municipalities decide to export waste instead of sending it to the incineration plant.
2. Unplanned termination of operations, e.g. due to environmental pollution.
3. Operating losses, e.g. due to uncertainty regarding sale of energy and products.
4. Risk due to technological development and changes in environmental legislation and regulations.

Many risk factors are inherent in the option of not building a waste incinerator but being dependent on other nations, oil prices, etc.

Conclusions

- Different risk factors found with different risk analysis methods.
- IPM is easy and fast but does not reveal nature of risk or causal relationship.
- VUCA gives more risk factors than IPM but requires knowledge and processing.
- STAMP helps develop the system, identify stakeholders, analyze the relationships needed between stakeholders for the system to function. With STPA the safe and secure control actions needed in the system can be defined in early design phase.
- Limitation:
  - Project has not started, no decisions have been made, limited data available, time required to analyze data, experts' knowledge needed to evaluate the data, an understanding of specific and complex systems, and changes that occur in perpetual systems over time.

Thank you for your attention

Questions ?

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