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H2-Expo
Standards and Safety Workshop

Quantitative Risk Assessment of a virtual "representative" Hydrogen Refuelling Station

Gerd Petra Haugom and Kjersti Holmefjord
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NOTE:

- ***The HRS analysed in this QRA is an example virtual HRS, not a standard or representative HRS.***
- ***For a real HRS a station specific QRA have to be carried out to reflect the risk at that actual station.***

Why QRA?

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QRA Objectives:

- Demonstrate safety challenges relevant for today's technological development
- Demonstrate how detailed risk assessments can be used in order to manage risk associated with HRSs

Why QRA?

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QRAs can be a very efficient risk management tool, particularly if used during the design of a HRS to evaluate different design solutions and optimise design with respect to risk and economical aspects

Examples:

- Optimise relative location of equipment, to prevent escalation and/or exposure of people to potential accidents
- Optimise shutdown segment sizes
- Assess the need for fire protection of equipment or support structure
- Assess the need for designing buildings against explosion overpressures

Based on QRA findings, risk reducing measures can be suggested; risk reducing effect of measures can be evaluated and used as input to cost benefit analysis

The virtual “representative” HRS

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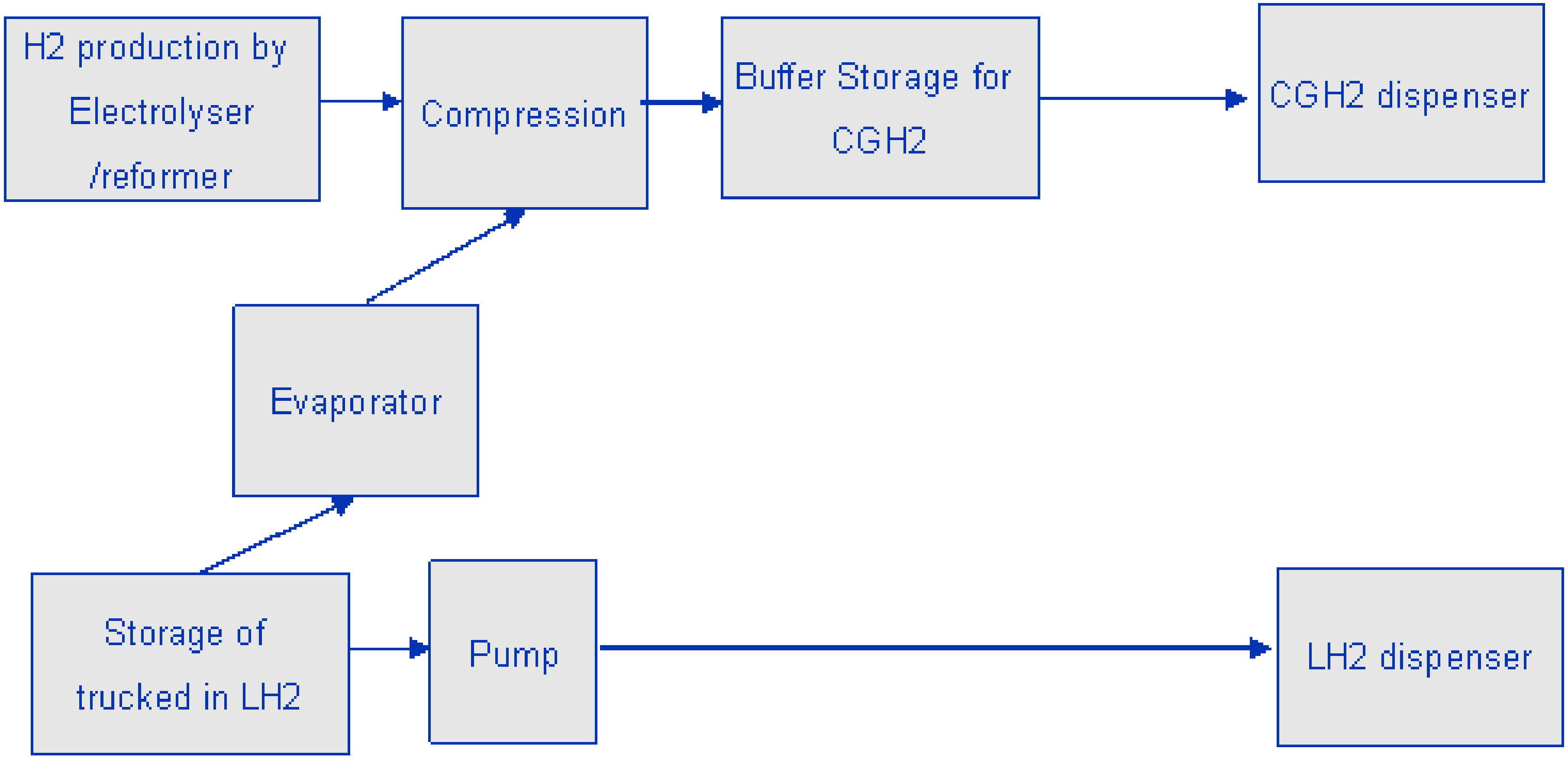

Virtual HRS – Layout of production and LH_2 unloading area

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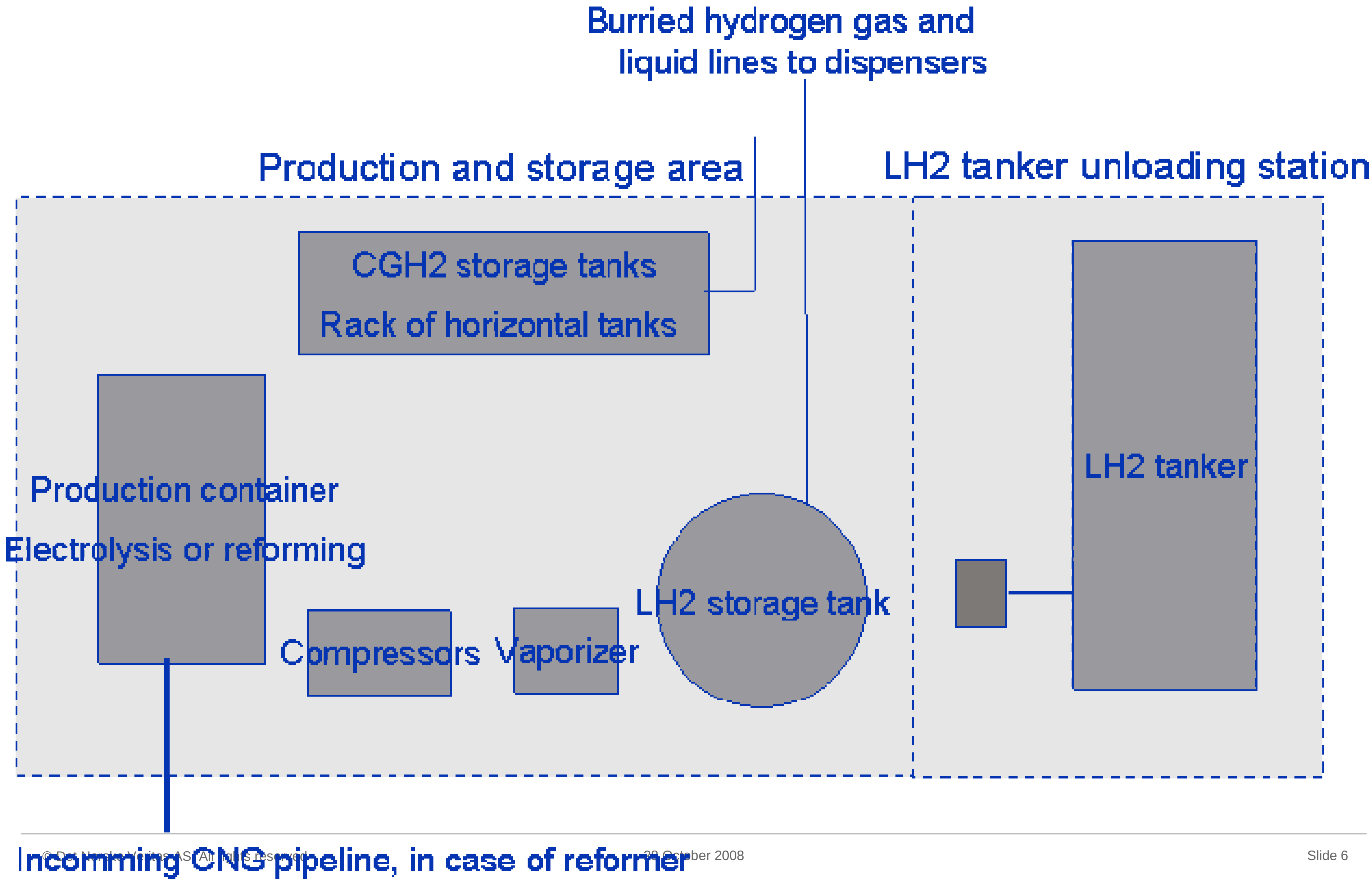
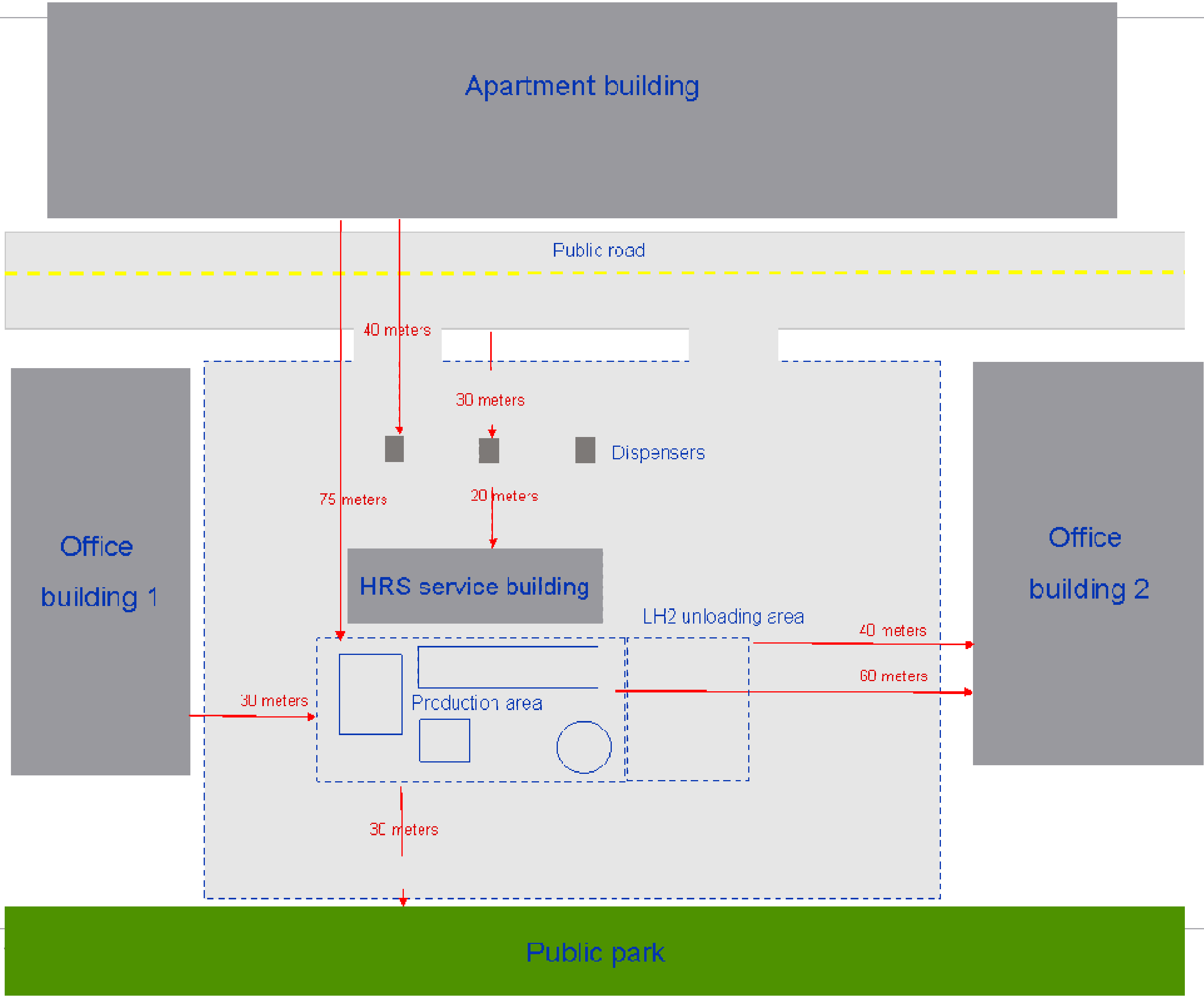
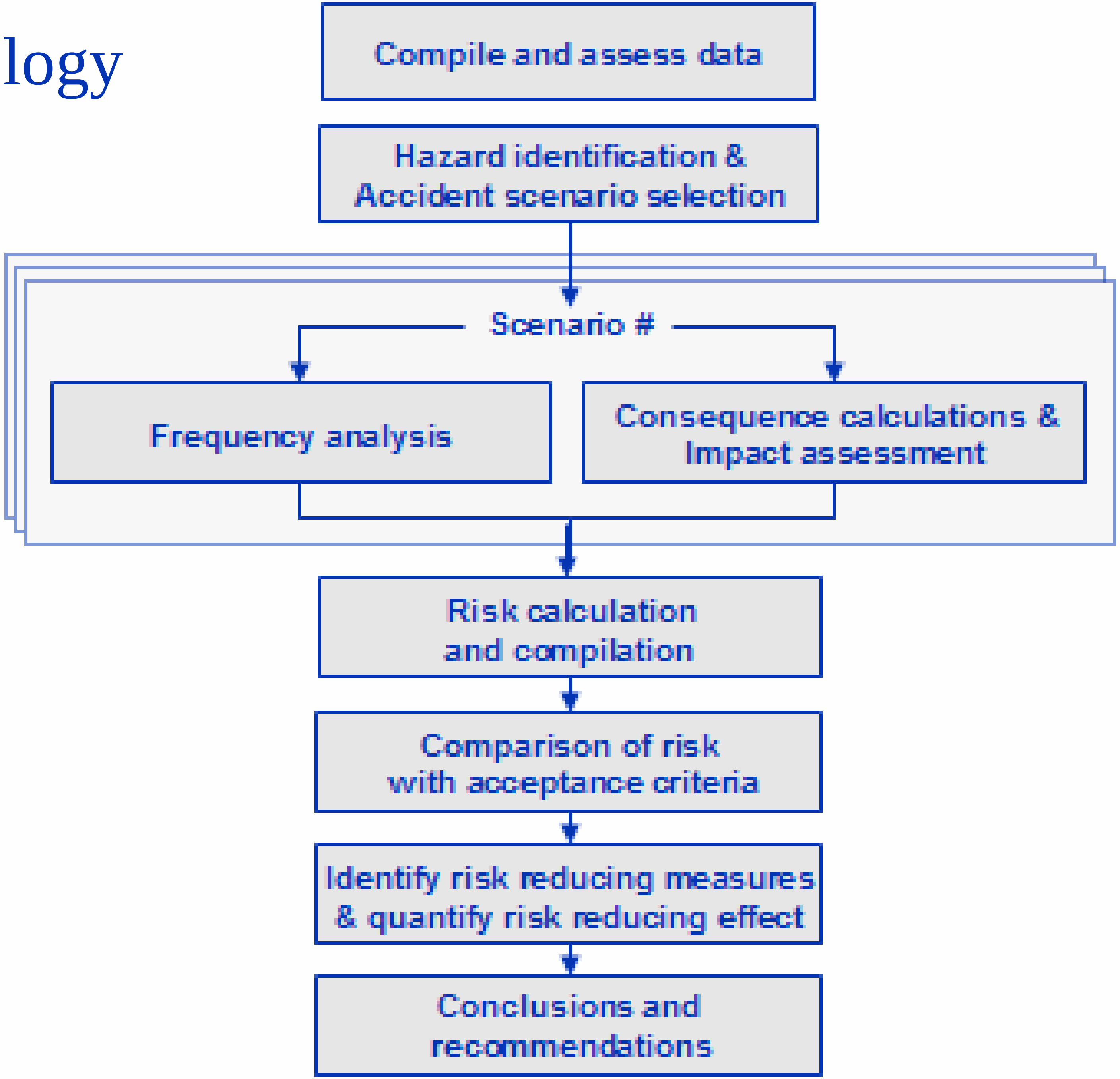


Layout of virtual HRS



Methodology



Risk to 1st party – employees at the HRS

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- Tolerable risk criteria:
  - *The individual probability of fatality should not exceed 10-4 per year* .
- The calculated risk to 1st party is well below the defined project tolerable risk criteria.

- Layout and HRS operation specific results:
  - For the HRS design assessed, the HRS personnel are most exposed to risk while they do the daily inspection of the production facility.
  - The risk for personnel is low while they are inside the service building.
  - Dispenser leaks give a low contribution to 1st party risk.

Risk to 2nd party – customers at the HRS

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- Tolerable risk criteria:
  - *The probability of a major accident causing one or more fatalities among customers shall not exceed 10-4 per year. This is the total number of fatalities among customers per year caused by the HRS.*
- The calculated risk to 2nd party is below the defined tolerable risk criteria
- Layout and HRS operation specific results:
  - The dispensers are the dominating contributor to the risk for 2nd party.
  - Incidents in the storage and production area will only give a small contribution to 2nd party risk.

Risk to 3rd party – Societal risk

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- Societal risk – were calculated in terms of:
  - Probability (per year) of exposing residential area, third party working premises or public assembly area outside the station to fatal exposure levels caused by major accidents at the station.
  - FN curve (Frequency per year of N or more fatalities, as function of N). If the calculated risk is above the red curve the risk must be reduced. If the calculated risk is above the green curve the risk should be reduced if feasible.

- Tolerable risk criteria:
  - *No residential area, third party working premises or public assembly area outside the station shall be exposed to fatal exposure levels caused by major accidents at the station of probability greater than 10-6 per year. If there are buildings surrounding the facility, fatal exposure due to collapse of these shall be taken into account.*

- *The 3rd party exposure frequencies are well below the defined tolerable risk criteria.*

FN curve for the example HRS

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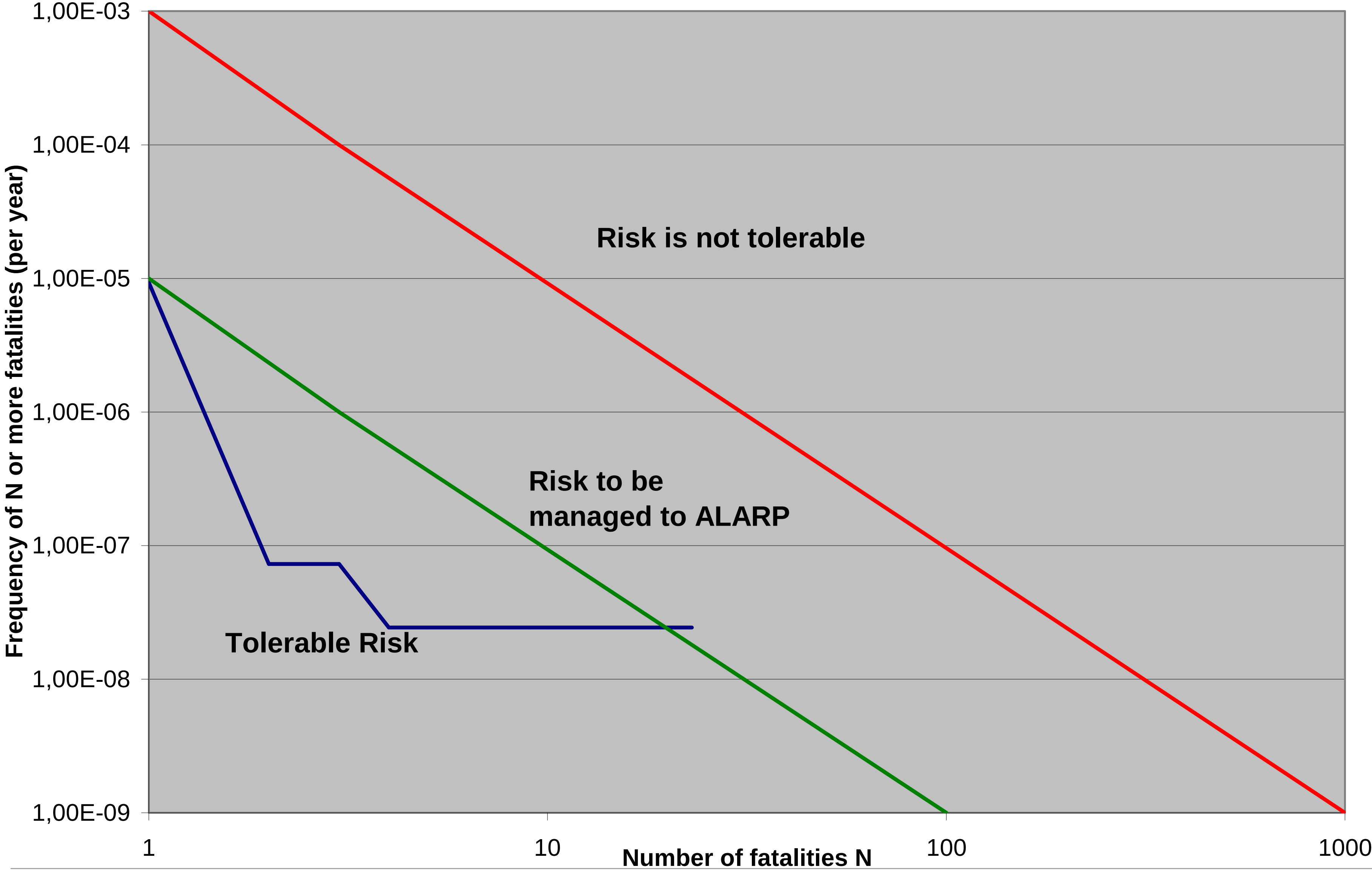

How input data and assumptions affect the results examples

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Layout and HRS operation specific results:

- Risk to 2nd party – customers at the HRS
  - For the example HRS a very effective measure to reduce the risk to 2nd party is to move the customers away or shield the customer from the dispenser / vehicle interface during refuelling
  - For the example HRS, removing assumed automatic gas detection system that initiate automatic shutdown from the liquid dispenser box will increase the 2nd party risk significantly.
  - A main reason is that most incidents identified were very local
  - Continuing focus on safety for the HRS user interface including related M-T-O issues is therefore important!
- CFD tools can be used to model ”high” risk incidents to optimise the HRS layout and associated risks.
  - Local geometry may have significant effect on the consequences of an incident.

Safe design and operation

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- Recommendations based on assumptions applicable for this QRA:
- Design
  - Careful selection of design standards to limit problems related to hydrogen embrittlement and corrosion.
  - Design systems to limit likelihood of potential jet fires to impinge on other equipment containing H2 or natural gas.
  - Vent release located to prevent ignitable gas from the vent reaching ignition sources at the HRS.
- Operation:
  - Establish operational and emergency procedures before the HRS is brought into operation
  - Regular inspection and maintenance in the operational phase
  - Regular periodic testing and calibration of safety systems

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Contacts:

Gerd Petra Haugom:
DNV Research and Innovation, Det Norske Veritas, Veritasvn 1. Høvik, N-1322 Norway *Gerd.Petra.Haugom@dnv.com*

Kjersti Holmefjord:
Kanfa AS, Nye Vakås vei 80, N-1395 Hvalstad, Norway
koh@kanfa.no

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