# Integrated tool for maintenance and refurbishment planning of hydropower plants
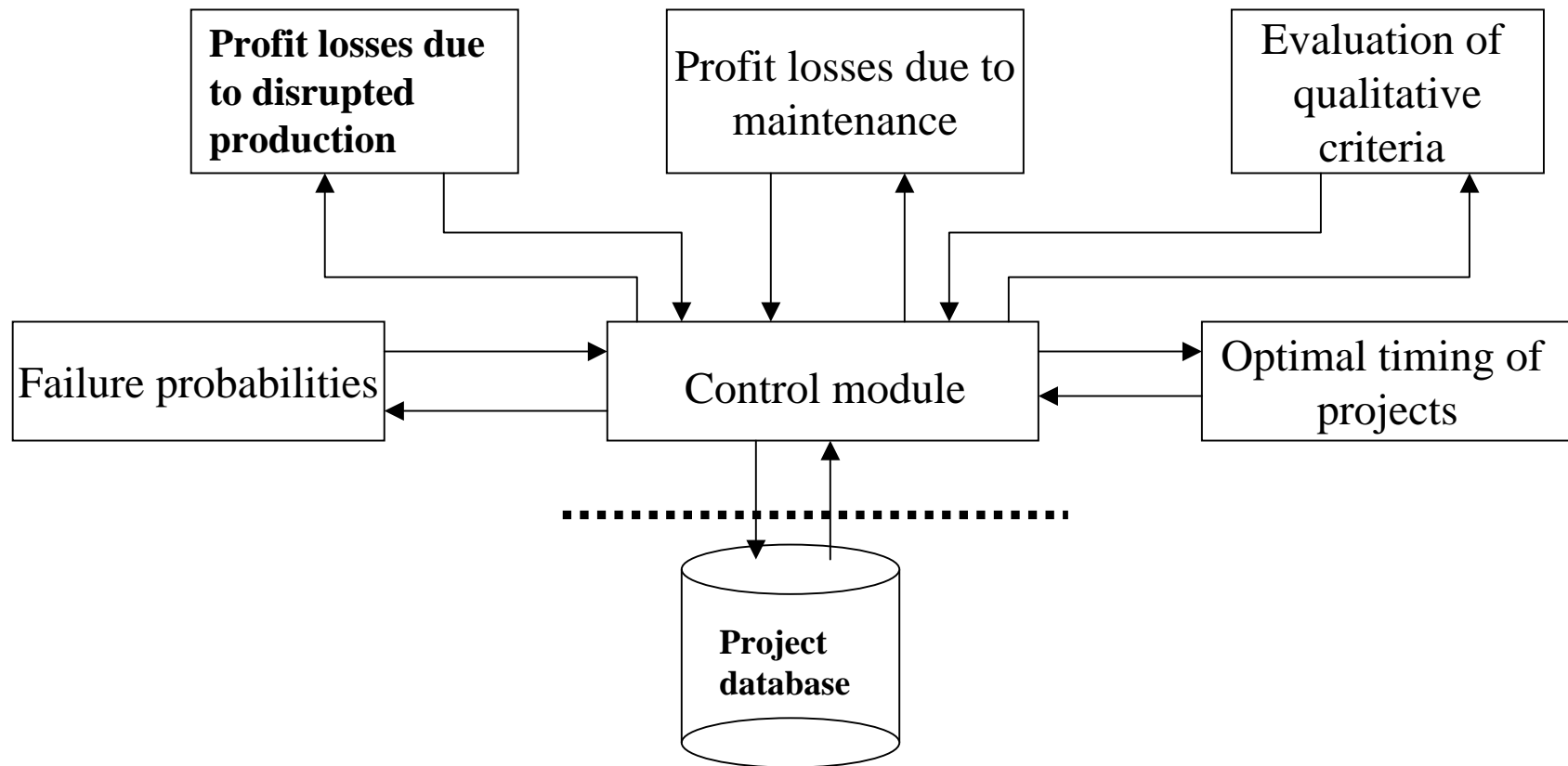
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# Model concept

- **Based on integration of modules that can be run separately**
- **Advantages**
  - ◆ **Make use of existing modules if possible**
  - ◆ **New modules can be used before the whole concept is finished**
  - ◆ **The whole concept may not be necessary for every decision problem**

# Model overview

# Profit losses due to disrupted production

- **Module based on existing hydropower scheduling model (EOPS model used by most utilities in Norway)**
- **Input to module**
  - ◆ **Physical description of hydro system**
  - ◆ **Inflow statistics**
  - ◆ **Future market prices (scenarios)**
- **Calculates expected losses due to disrupted production for a given plant failure. Probability distribution for losses is also available**

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# Profit losses due to maintenance

- **Module also based on the EOPS model**
- **Same input as for the previous module**
- **The user specifies which plant, length of maintenance and possible maintenance period (e.g. next year)**
- **The model calculates automatically expected profit losses for all possible maintenance periods (e.g. week 20-26, 21-27, 22-28 etc)**

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# Evaluation of qualitative criteria

- **Standardized procedures for evaluation of project's non-economic (qualitative) utility value**
  - **Health,Environment and Safety**
- **Objectivity and consistency when comparing projects**
- **Improved documentation of projects**

- **Existing commercial software or make a new tool**
  - **Communication with other modules**

# Failure probabilities

- **Output from module is failure probabilities as function of time of use for each unit (turbine, generator and control system)**
  - **Only failure that leads to disrupted production**
- **Based on:**
  - **Statistics**
  - **User knowledge**
  - **Operation patterns, maintenance actions etc**

# Optimal timing of projects

- **Input**
  - ◆ **List of possible projects including:**
  - ◆ **Failure probabilities, expected profit loss due to disrupted production, expected profit loss due to maintenance and investment cost**
- **Output:**
  - ◆ **A list of projects to carried out in the current year a maintenance schedule for the rest of the planning period.**
- **Optimisation based on dynamic programming**
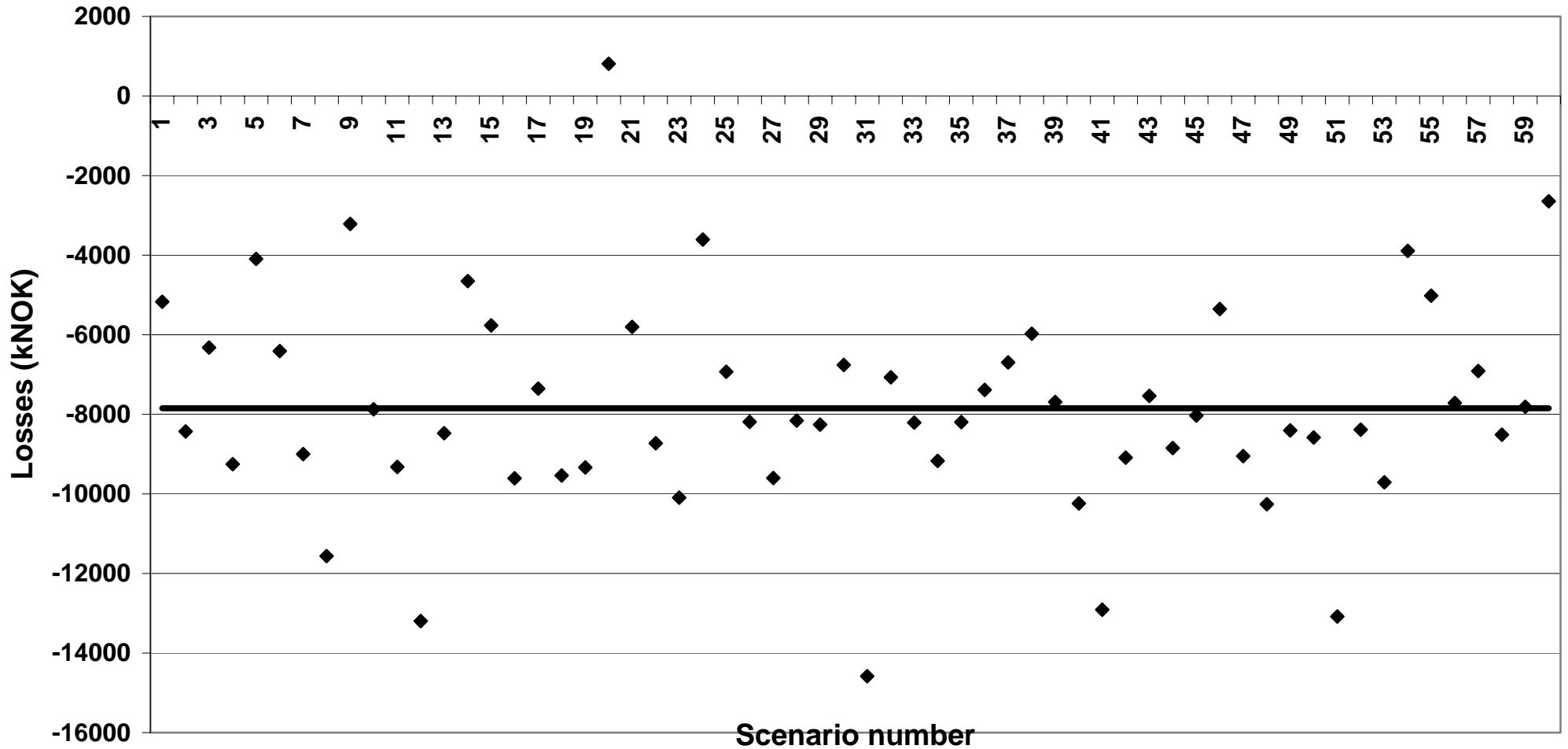
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# Status/benefits

- **Model development started in year 2000**
- **Based on earlier work and models**
- **The whole integrated concept is scheduled to be finished in 2005**

- **Automate/simplify computations**
- **Consistent weighting of non-economic criteria**
- **Documentation of decisions**
- **Optimal timing**
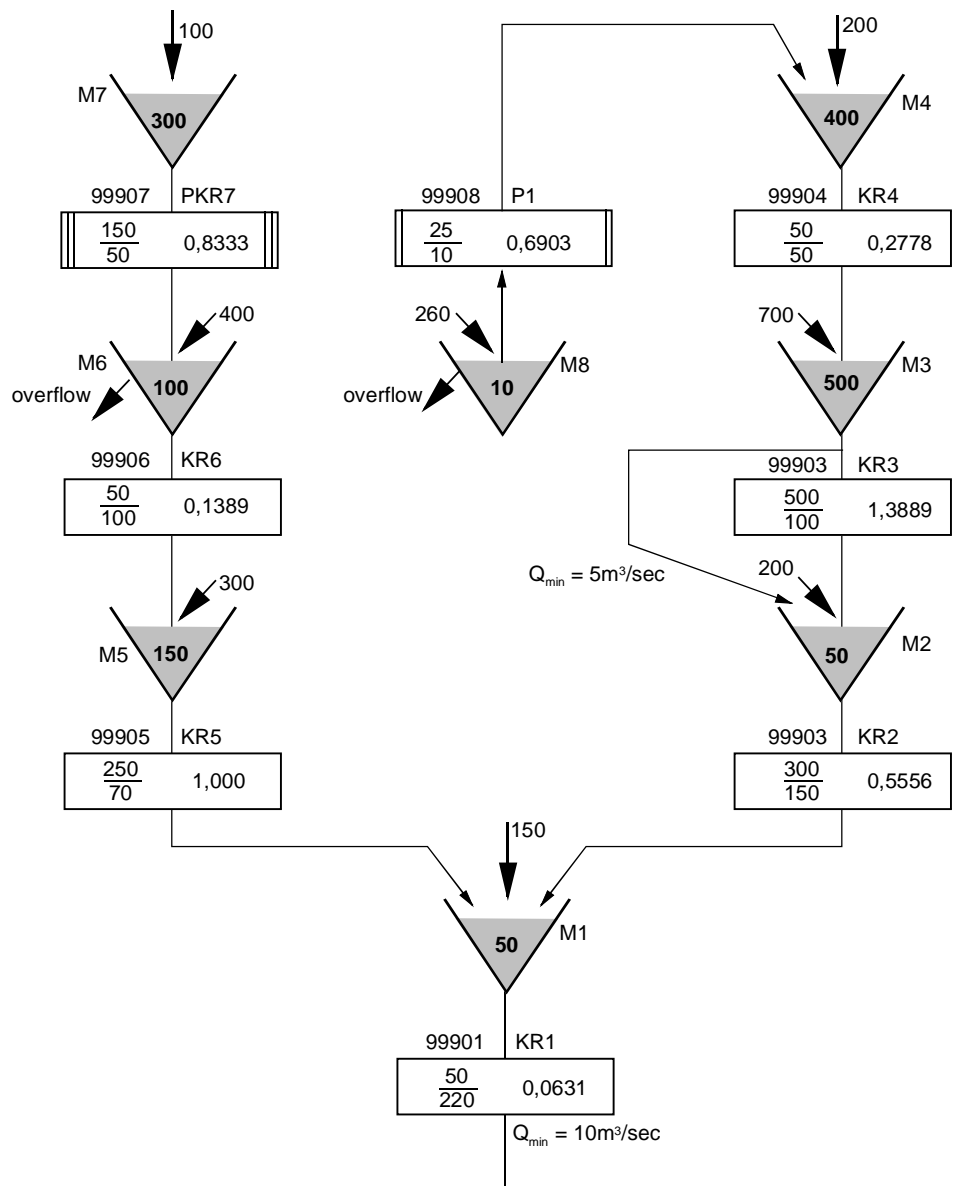
# Losses due to disrupted production in KR4 for week number 6-14

Losses due to disrupted production in KR4 for week number 21-29