SLAJD 01

EC CONCERTOII project REMINING-Lowex

Economical & energetic parameters of minewater as an energy source
WP4.3 Method and case studies

Erwin Roijen
Cauberg-Huygen Consulting Engineers
Maastricht, the Netherlands

SLAJD 02

Sensitivity study on economical and energetic parameters of minewater as an energy source

- Direct heating and cooling buildings by mine water versus minewater as a thermal half fabricate, which needs post processing.

-The overall energy costs and performance of heating and cooling with mine water, compared to traditional solutions (based on fossil fuels).

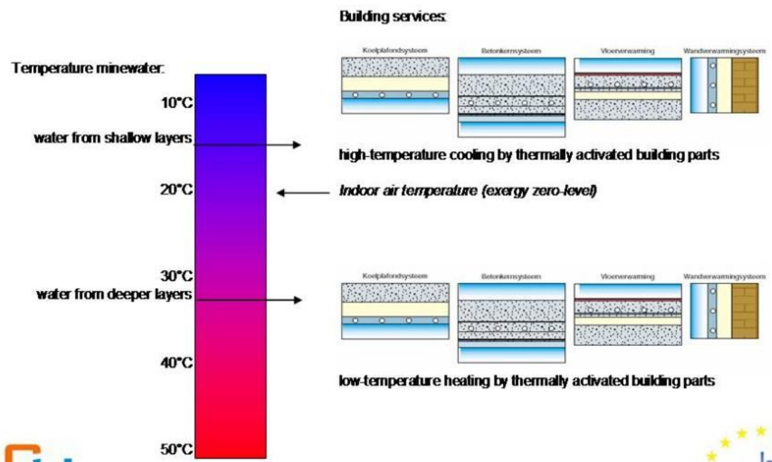
SLAJD 03

Feasibility

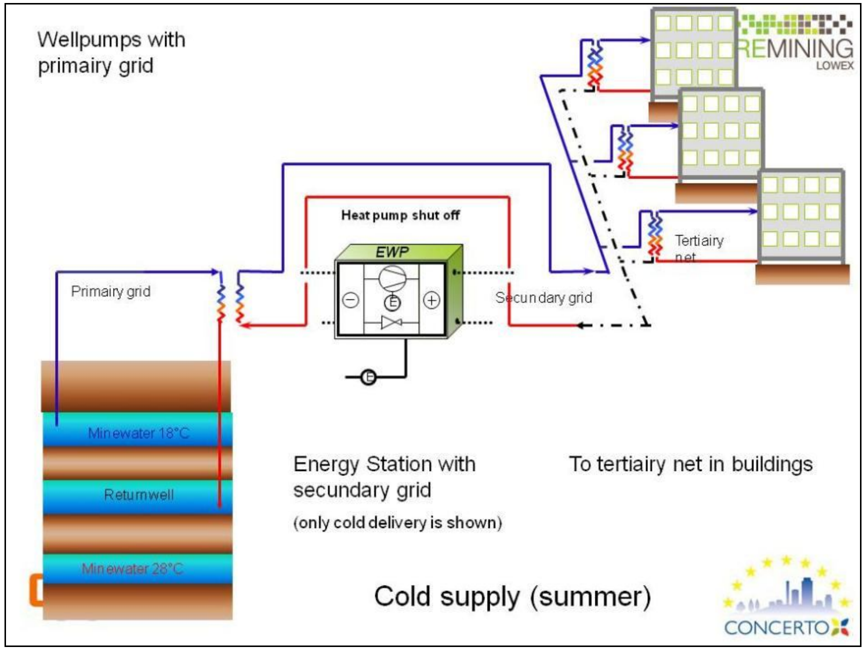
- Calculations with exploitation models
  - Business plan and financial forecast (Mine water production company, MPC)
  - Business plan and financial forecast (Mine water energy company, MEC)
- Sensitivity analyses
  - Investments
  - Energy prices
  - Pumping costs

SLAJD 04

Direct heating and cooling



SLAJD 05

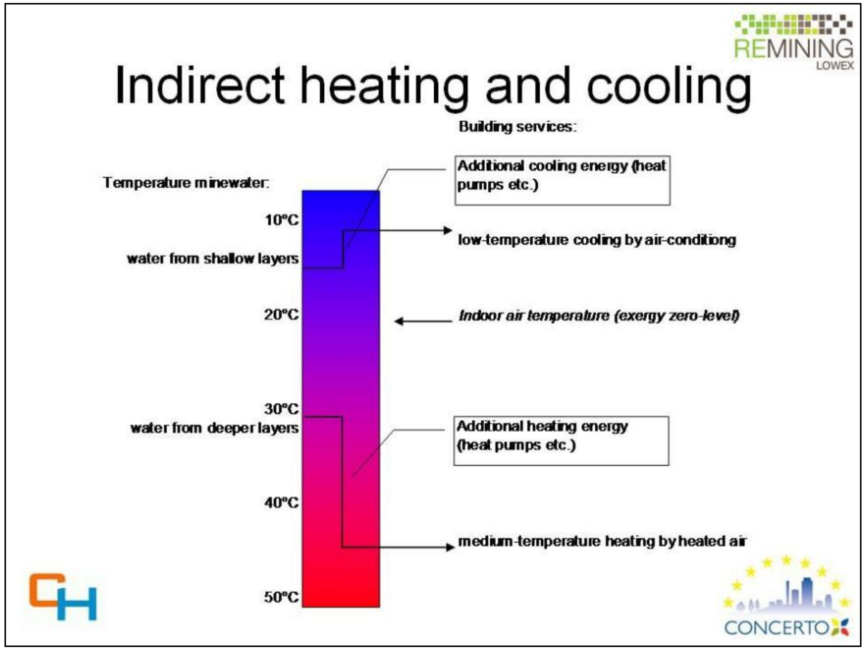


SLAJD 06

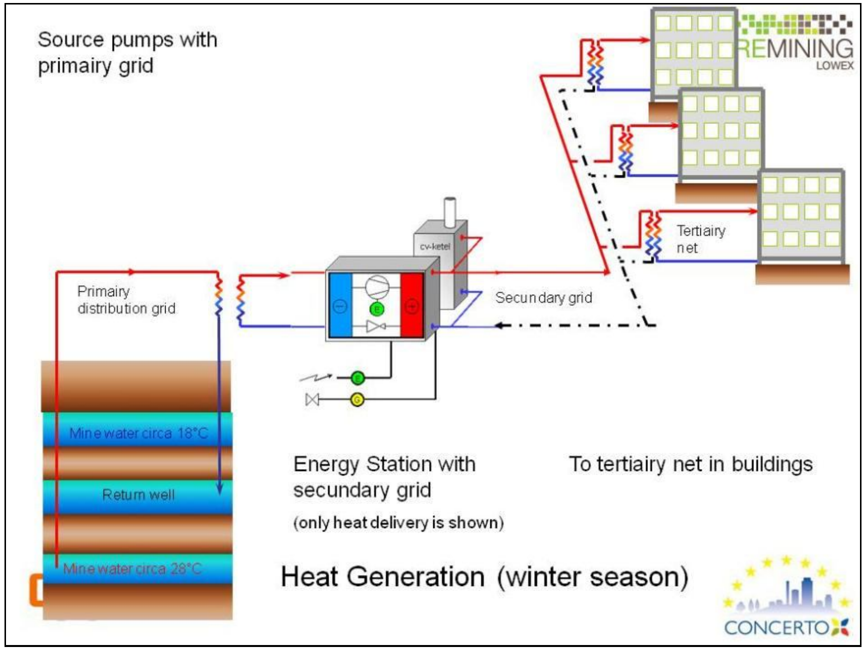
Boundary conditions

- Hydraulic separation between the mine-water system and the building services
- The heating and cooling capacity of thermally activated building parts is limited. The system is sensitive to excessive transmission and ventilation losses.

SLAJD 07



SLAJD 08



SLAJD 09

Indirect heating and cooling

Depending on the kind of minewater reservoir and the location of the buildings, more or less investments have to be done for:

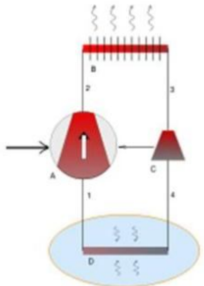
- drilling and development of the wells;
- pumps and pipelines for transportation of the minewater;
- heat exchangers and filters;
- heat pumps and/or gasfired boilers;
- Management, control and maintenance of the system

SLAJD 10

Post processing minewater heat by heat pumps

Coëfficiënt of Performance (COP)

Heating system		ΔTevap	Efficiency or COP*	PER**	CO_2-reduction
Reference	0. Ref. Gas fired boiler HE	n/a	0,95	0,95	0 % (ref.)
	1. Ref. HP brine / water (12°C / 35°C)	6°C	4,2	1,68	43 %
	2. Ref. HP brine/ water (12°C / 55°C)	6°C	3,1	1,24	23 %
High tempera-ture heating (>55°C)	3. HP mine water / water (25°C / 55°C)	6°C	4,0	1,60	40 %
	4. HP mine water / water (25°C / 55°C)	10°C	3,3	1,32	28 %
	5. HP mine water / water (25°C / 55°C)	15°C	2,9	1,16	12 %
Low temperature heating (35°C) [low-ex]	6. HP mine water / water (25°C / 35°C)	6°C	6,0	2,40	60 %
	7. HP mine water / water (25°C / 35°C)	10°C	4,8	1,92	50 %
	8. HP mine water / water (25°C / 35°C)	15°C	3,8	1,52	37 %



SLAJD 11

Example

- Heat demand of apartment: 10 GJ
- Fossil heating: 330 kg of coal/year
- Minewater heating COP = 5:
  - 550 kWh electricity (power plant 140 kg coal)
  - 200 m^3 of minewater

SLAJD 12

Capital costs of the minewater infrastructure and building services

In relation to the outline of the minewater reservoir and the location of the buildings, more or less investments have to be done for:

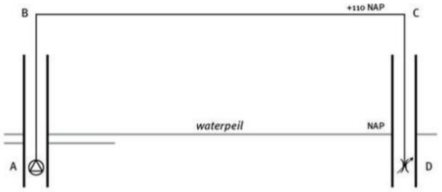
- drilling and development of the wells;
- pumps and pipelines for transportation of the minewater;
- heat exchangers and filters for handling over the energy;
- Management, control and maintenance of the system

SLAJD 13

Running costs for pumping and distribution

PER Heat Extraction [°C]	total pump pressure difference [bar]				
	5	10	15	20	25
2	3,6	1,8	1,2	0,9	0,7
4	7,3	3,6	2,4	1,8	1,5
6	10,9	5,4	3,6	2,7	2,2
8	14,5	7,3	4,8	3,6	2,9
10	18,1	9,1	6	4,5	3,6

Pump energy Heat extraction [°C]	total pump pressure difference [bar]				
	5	10	15	20	25
2	28%	56%	83%	111%	143%
4	14%	28%	42%	56%	67%
6	9%	19%	28%	37%	45%
8	7%	14%	21%	28%	34%
10	6%	11%	17%	22%	28%

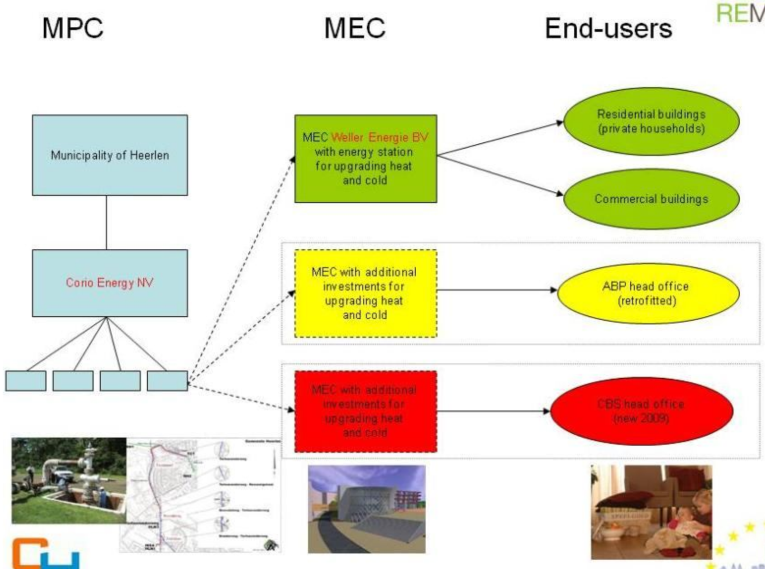


SLAJD 14

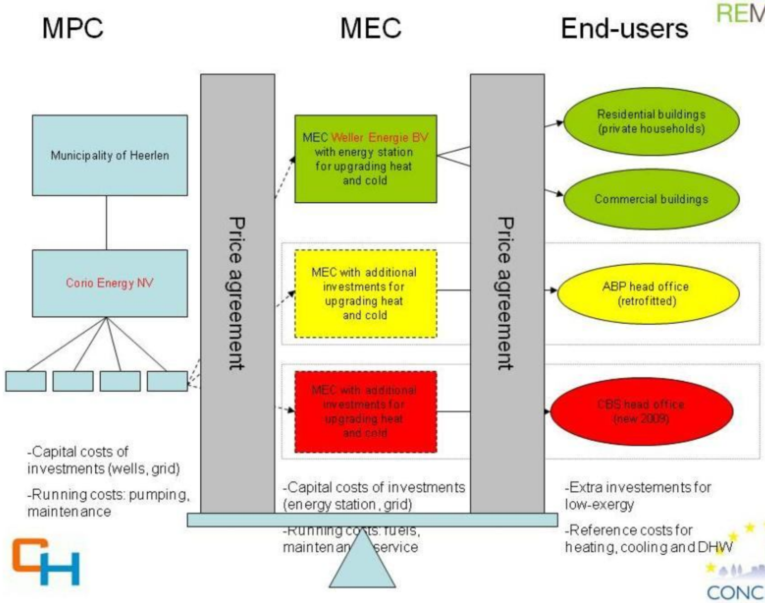
Exploitation parameters assessment

- Definition of energy plant and building services including boundaries
  - Mine water production company MPC delivers half-fabricate to energy stations MEC
  - Heat exchangers are physical demarcations
  - Post-processing is expensive, but necessary
- Volumes of investment
  - Primary investments: wells, distribution grid, energy stations
  - Secondary investments: low-ex buildings
- Return of investment
- Economical life span vs. technical life span

SLAJD 15

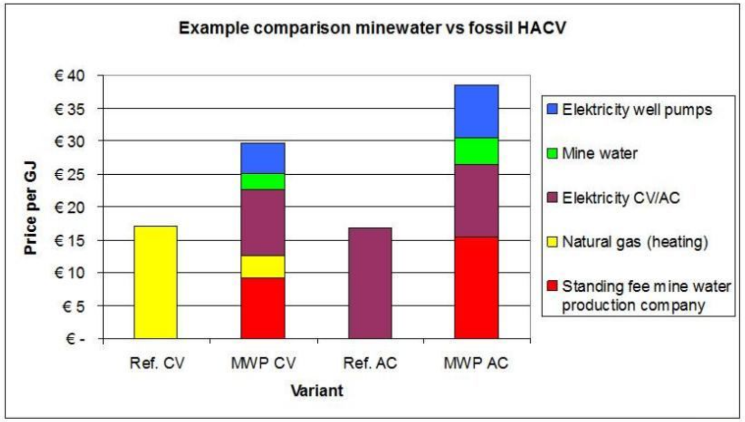


SLAJD 16



SLAJD 17

Example mine water value



SLAJD 18

Contracting

- Negations with possible customers
  - Guarantees on delivery of minewater
  - Temperatures and quantities of minewater
- Settlement of final delivery contracts
  - Connection and delivery conditions between MPC and MEC
  - Connection and delivery conditions between MEC and end users as well as MPC with end users

SLAJD 19

Economical barriers

- High investments for infrastructure
  - Wells (if needed)
  - Distribution system
- Hardly any energy to sell for heating and cooling in very energy efficient buildings
  - Shift from selling GJ's to connection fees and/or one-off contribution fees
  - HT Cooling can give more profits
- Cost for electricity (pumps, heat pumps) are still substantial
  - Pump energy: how to reduce?
  - Buildings really need to have optimal low-ex emission systems
    - to limit additional use of heat pumps
    - to have relative large ΔT

SLAJD 20

Concluding (1)

- The energetic and financial performance of minewater as an energy source depends on a variety of parameters. Therefore, a field of expertises is needed to come up with a solid overall view.
- A basic calculation model which compares a minewater energy system to a conventional system at a unit level of 1 GJ is used to identify them.
- Residential buildings: what to do with domestic hot water?
- Important parameters are:
  - direct or indirect heating and cooling by minewater (practice: mix of systems)
  - effectiveness of pumping and distributing the minewater
  - type of ownership of the wells and/or the buildings
  - cost of capital for the investments
  - cost of fossil energy (natural gas versus electricity) and their future price development

SLAJD 21

Concluding (2)

- Direct heating and cooling is strongly preferred because of
  - the higher energy savings,
  - the clear structure of costs,
  - relatively low investments,
  - less dependency on fossil fuel prices.
- A disadvantage of direct heating and cooling with the minewater is the sensitivity for fluctuations of the minewater temperature (if any).
- The overall performance of the pumping and distribution of minewater can be improved by:
  - creating a closed loop between the wells (reduces hydrostatic pressure difference)
  - by a turbine in the injection well (generates electricity from the falling water).
  - both techniques need more study.

SLAJD 22

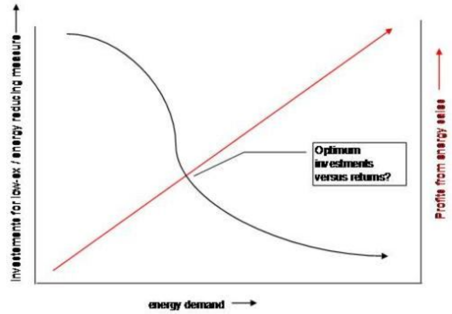
Concluding (3)

- The unit pricing of the minewater (tariff) can be put in
  - the volume consumption (m^3 of minewater)
  - the extracted energy (GJ) from the minewater.
- The first option allows relatively simple contracts between supplier and demander and stimulates the demander for maximum energy extraction. In the second case, the GJ-price for a half fabricate of energy should be defined at clear conditions like the minimum temperature difference for energy-extraction.
- Furthermore, the allocation of the cost for extra investments in the buildings like back-up systems and a low-exergy HVAC-system requires negotiations between the supply- and demand side of minewater energy.
- For a solid business case, the supplier of minewater energy can state a fixed standing right to cover up his capital costs and a variable price (€ per GJ or m^3) to cover up the pump- and distribution costs (running costs).

SLAJD 23

General recommendations

- A small as possible distance between the minewater source and the energy demanders
- Matching temperatures for minewater versus building services
- An open business model with a clear financial forecast appoints the economic and energetic return of the system



SLAJD 24

Technical analysis Czeladz

(Saturn pipeline & new real estate)

- Temperature 12,2 -14,4°C: suitable for indirect heating (heatpumps) and free cooling
- Building density area for district heating: 75 apartments / ha
- 11 mln m^3 minewater:
  - 400.000 GJ heat (≈ 28.000 apartments)
  - OR 250.000 GJ cold (≈ 50.000 apartments)
- Domestic hot water?
- Pumping 24/7?