



LESAM 2017
NTNU, Trondheim, Norway

Keynote:

**Trade-off between Total Cost and
Reliability, / Gunnar Mosevoll, Norway**



«Trade-off between total costs and reliability»

Dr. Ing. Gunnar Mosevoll, Skien, Norway

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1. «Trade-off between total costs and reliability»

- Some definitions
- Setting the goals for reliability and planning of the needed measures
- Situations of reduced reliability
 - ▶ Example a: Resource costs (water shortage – opportunity costs of water use)
 - ▶ Example b: Social costs (insufficient water treatment combined with internal corrosion in distribution an service pipes)
- Using the water supply and sewerage utilities as taxation objects:
Does high taxes reduce the total reliability of the water supply and sewerage services ?
- During the last 40 years the pipe materials are improved:
How to record information on increased reliability ?
- A small error repeated many times:
How to prevent errors like that ?

Reliability and risk: Some definitions

Reliability: The ability of a system or component to perform its required functions under stated conditions

Risk: The risk is quantifying the potential loss of a specified event or condition

$$\text{Risk} = \text{Probability} \times \text{Consequence}$$

Consequence: A **large** consequence can be:

- one large and severe event or condition (example: a severe water shortage) **or**
- a large number of the same and minor event (example: an systematic error repeated many times)

Producing water and sewerage services: Balancing performance, risk and costs

When balancing the performance, risk and costs we need to describe:

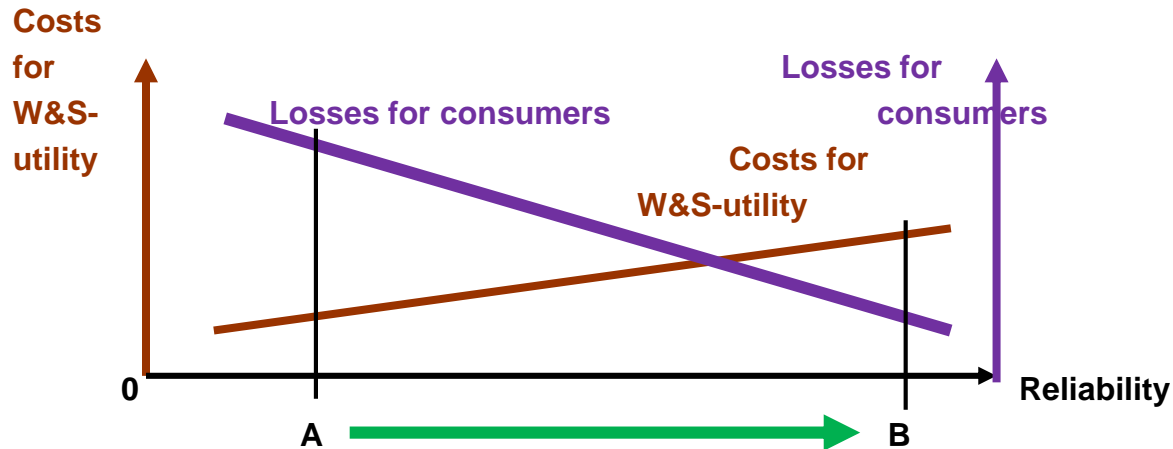
- Water and sewerage services: **Extent and quality**
- Costs: **Category**
- Treatment plants and water transportation network: **Capacity and useful lifetime**
- Financing: **Category**
- Price: **Price policy and indirect effects**
- Natural monopoly: **How to produce the services in a sustainable way and to low costs,**

Reliability is used in the description of the quality of the water and sewerage services.

Categories of costs

- **Operations and maintenance costs**
- **Capital costs**
 - **Interest and principal payments**
 - **Real interest rate / opportunity interest rate**
 - **Depreciation**
- **Resource costs (opportunity costs of water use):**
 - **Present situation**
 - **Future situation**
(impact of climate changes ?)
- **Environmental damage costs**
 - Degradation and depletion by water extraction and by emission of pollutants:**
 - **Present situation**
 - **Future situation** (climate changes ?)
- **Social costs** **Example: Incidents with not safe water**
- **Long run marginal costs** **Extension of capacity, water extraction**

2. Trade-off between total costs and reliability: Setting the goals and planning of the needed measures



The losses for the consumers include both tangible and intangible losses

A is the present condition. B is the goal.

How to go from condition A to condition B ?

3. Situations of reduced reliability

Example a: The water resources are insufficient and the water consumption has to be reduced

It may be difficult to imagine and weigh the many consequences of a severe water shortage.

Reduction of the leakage loss in the water distribution network is a usual measure against such vulnerability.

When weighing **resource costs** and the risk of reduced quality of the water services it is useful (**necessary ?**) to study experiences from similar cases. **Hard measures may be needed.**



Some water utilities may benefit from the experiences in Sao Paulo in Brazil 2014 – 2015.

Some water crisis are more worse than this; others are less worse. However, the Sao Paulo crisis is worth to study.

The water shortage in São Paulo, Brazil 2014 – 2015: A large water crisis I

The British newspaper [the guardian](#) had
a series reports from the water crisis in Sao Paulo:



www.theguardian.com

5 Sept 2014: Brazil drought crisis leads to rationing and tensions:

Water rationed in 19 cities in southeast and central regions after usual abundant supplies run dry.

11 Febr 2015: Brazil drought: Water rationing alone won't save Sao Paulo:

The solutions to the severe drought in Brazil must go deeper than water rationing and pressure changes, says the Alliance for Water network.

Sao Paulo city: 12 million inhabitants

Sao Paulo city + the areas surrounding Sao Paulo: 20 million inhabitants

The water shortage in São Paulo, Brazil 2014 – 2015: A large water crisis II

Report from the British newspaper [the guardian](#) :

25 Febr 2015: São Paulo – anatomy of a failing megacity:
residents struggle as water taps run dry :

Many «paulistanos» are hoarding water in their apartments – and some are even drilling homemade wells – as they prepare for possible rationing.

- In part a result of badly stored water, instances of dengue fever spread by mosquitos almost tripled in January, compared with the previous year.

Graphic designer Isabella Sacramento, 33, lives in a neat, well maintained apartment complex in the neighbourhood of Saúde. South-central São Paulo:

- **On the third day without water**, residents set out rows of plastic chairs in the communal area and held emergency meeting to discuss the problem. But to Berger's dismay, the meeting quickly descended into furious argument:
«I'd always imagined people would try and help each other out in a crisis situation,» she says. «But it's not what happened at all.»

4 days
without
water
supply

*The water shortage in São Paulo, Brazil 2014 – 2015:
A large water crisis III*

Report from the British newspaper [the guardian](#) :

15 April 2015: São Paulo's water crisis: in the Favela do Moinho, 2 500 residents rely on one impossible thin blue pipe:

How water shortages are affecting the city's poorest residents in central São Paulo's last remaining slum.

- Many, including most Favela do Moinho residents, don't have water tanks, making it all the more difficult to cope when the taps run dry – as they do, daily, for millions in the city, any time from 2 pm onwards.

<http://www.theguardian.com/cities/2015/feb/25/sao-paulo-brazil-failing-megacity-water-crisis-rationing>

<http://www.theguardian.com/cities/2015/apr/15/sao-paulo-water-crisis-favela-shortages-poorest>

<http://www.theguardian.com/cities/2015/feb/25/sao-paulo-brazil-failing-megacity-water-crisis-rationing>

If the water resources are insufficient and the water consumption has to be reduced: «*The Danish method*» may be a solution ?

It is normally necessary to reduce both

- the private water consumption and
- the leakage loss.

There are several different incentives to reduce the total water consumption.

Denmark has done it in a very effective way:

Charging a high tax on both the private water consumption and the leakage loss.

Both are strongly reduced; especially the leakage loss.

The hard work has lasted for many started many years ago. Few countries has now a lower leakage loss than Denmark.

In 2017 the water tax in Denmark is DKK 6,25 /m³ + added value tax.

The water tax is about 40 % of the total water price.

(Denmark has a similar tax on wastewater. This is a pollution tax, and it is much lower than the water resource tax.)



3. Situations of reduced reliability

Example b: A catastrophe with high **social costs**:

What can we learn from that ?

**When the «incomprehensible» happens: Example Flint, Michigan, USA
2014 - 2017**

**Wikipedia
has this summary
of the case:
(May 2017)**

Flint water crisis	
Time	April 2014; 3 years ago (April 2014) – present
Duration	Ongoing
Location	Flint, Michigan , United States
Type	<ul style="list-style-type: none"> •Water contamination: •Coliform bacteria •THMs •Lead •Possible Legionnaires' disease outbreak
Participants	Residents of Flint, Michigan
Outcome	<ul style="list-style-type: none"> •6,000–12,000 children exposed to lead^[1] •Public health state of emergency •Several lawsuits •Several investigations •Four resignations •Four firings •Five suspensions •Thirteen criminal indictments
Deaths	14
Non-fatal injuries	6,000-12,000

197

https://en.wikipedia.org/wiki/Flint_water_crisis

The city of Flint is now under way with major improvements



The city of Flint have now improved the **water quality**.

Flint has also started **the replacement of service pipes of lead**.

How long time will ittake before the consumers again **trust** the water utility?

[Pipes at 1,139 Homes Replaced So Far through Mayor's FAST Start Initiative](#)

FLINT, Mich. — Lead-tainted service lines at 253 homes have been replaced so far in Phase 4 of Mayor Karen ...
[Read More](#)

May 23, 2017 / [Home Page](#), [Mayor's Office](#), [News And Events](#), [Press Releases](#), [Updates on FAST Start](#), [Water & Utilities](#)

A catastrophe with high social costs: What can we learn from that ?

Possible preventative measures in the water supply utility?

- ▶ **More basic knowledge to degradation processes in the water supply network**
- ▶ **Good routines for internal warning**
- ▶ **Good risk analysis for events with serious consequences.**

4. Using the water supply and sewerage utilities as taxation objects

Does high taxes reduce the total reliability of the water supply and sewerage services ?

Denmark: Is the high taxes to the government, especially on drinking water, still necessary to keep the leakage loss low ?
Does the high tax lead to reduced investments and reduced reliability ?

Berlin, Germany: In 1999 the city of Berlin sold 49,9 % of the shares in the water supply and sewerage utility to private companies.
The city of Berlin needed the money for other purposes.
In 2013 the city of Berlin bought it back.
The utility had to pay high interest rates for the private capital.
Was the normal investment in the utility influenced by the costs of the private investment ?

Greece: EU is forcing Greece to sell off water and sewerage companies to pay the Greece debt. Is increased water prices the best way to pay for the debt of a country ?

5. During the last 40 years the pipe materials are improved: How much have the reliability increased ?

- During the last 40 years the pipe materials are improved:
How to record information on increased reliability ?

The quality of pipes of ductile iron, PVC-U and PE improved significantly.
The expected lifetime has increased.

The estimates of “**useful time**” and
“**survival function**” have to be revised for
these improvements.

How to record:

- The changes in the quality of pipe materials
- The failure / leaks (location, type and size)

An important feedback in innovation work for better pipes !



6. A small mistake which is repeated many times: How to prevent systematic mistakes like that ?

Example x:

The **electro fusion socket** was not properly supported during the fusion.

This fusion joint will therefore not stand for 100 year (probably less than 50 years)



Example y:

We may not know enough about the long term strength a rubber sealed joint.

Will the useful lifetime reach 100 years ?

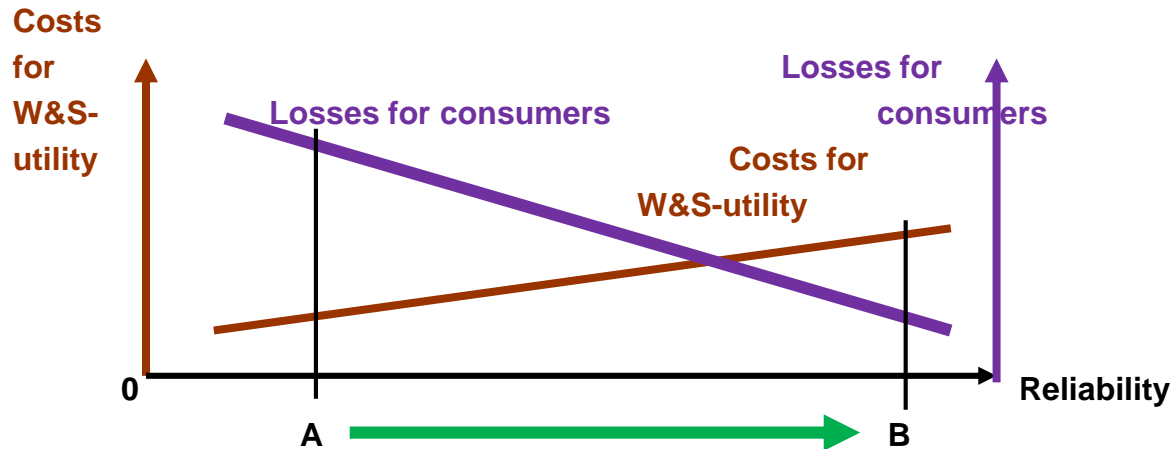
A report from Swedish water:

«Life-time prediction of rubber sealed joints for water and sewer pipes»

Kristian Thørnblom Jan Henrik Sallstrom Gunnar Bergstrøm

http://vav.griffel.net/filer/SVU-rapport_2014-04.pdf

7. Final remarks



The losses for the consumers include both tangible and intangible losses

A is the present condition. B is the goal.

How to go from condition A to condition B ?