NRW as % of System Input Volume just doesn't work!

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Innovative Solutions to Leverage Performance in Water Industry

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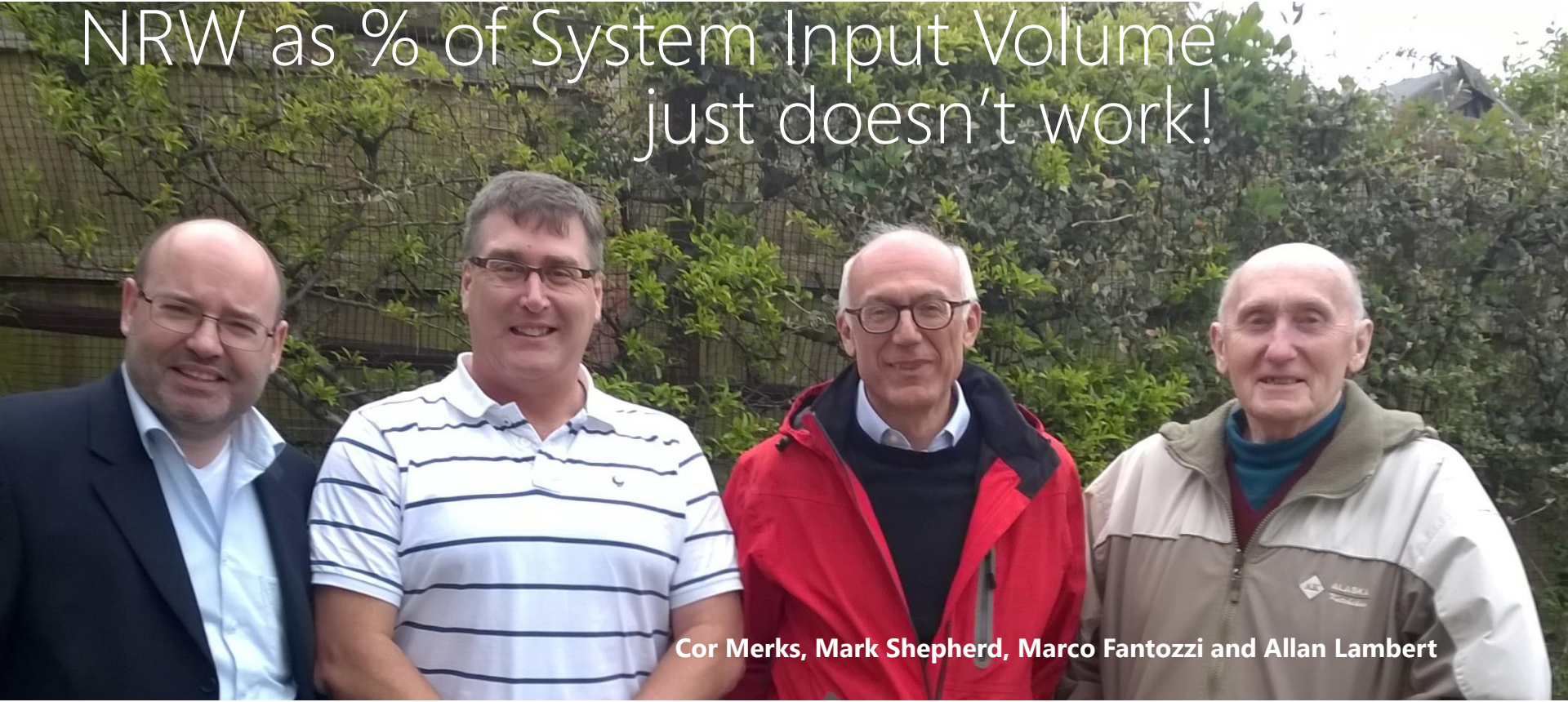
NRW as % of System Input Volume just doesn't work!



Cor Merks, Mark Shepherd, Marco Fantozzi and Allan Lambert

Performance Indicators (PIs) for Water Supply Services

"An individual Performance Indicator should be unique and collectively appropriate for representing all the relevant aspects of an *utility's* performance in a true and unbiased way, thus reflecting the managing activity. Each performance indicator should contribute to the expression of the level of actual performance achieved in a certain area and during a given period of time, allowing for a clear comparison with targeted objectives and simplifying an otherwise complex evaluation."

3rd Edition (2017) of *Performance Indicators for Water Supply Systems*.

The PI set related to environmental and economic water losses

Indicator	Sub-indicator	Definition
WR1		Inefficiency of use of water resources (%) Percentage of water that enters the system and is lost by leakage and overflows up to the point of customer metering.
Fi46		Non-revenue water by volume (%) Percentage of the system input volume that corresponds to non-revenue water.
Fi47		Non-revenue water by cost (%) Percentage of the system input volume that corresponds to the valuation of non-revenue water components.

3rd Edition (2017) of *Performance Indicators for Water Supply Systems*.

The IWA PI set related to operational water losses (1 of 3)

Indicator	Sub-indicator	Definition
Op23		Water losses per connection (m^3/connection/year) Total (apparent and real) losses, expressed in terms of annual volume lost per service connection. This indicator is adequate for urban distribution systems.
Op24		Water losses per mains length (m^3/km/day) Total (apparent and real) losses, expressed in terms of annual volume lost per mains length. This indicator is adequate for bulk supply and low service connection distribution systems.
	Op25	Apparent losses (%) Percentage of the water provided to the system (system input volume minus exported water) that corresponds to apparent losses. This indicator is adequate for urban distribution systems.

3rd Edition (2017) of *Performance Indicators for Water Supply Systems*.

The IWA PI set related to operational water losses (2 of 3)

Indicator	Sub-indicator	Definition
	Op26	Apparent losses per system input volume (%) Percentage of the water entering the system (exported water inclusive) that corresponds to apparent losses. This indicator is adequate for bulk supply and low service connection distribution systems.
	Op27	Real losses per connection (l/connection/day when system is pressurised) Real losses, expressed in terms of the average daily volume lost per connection. This indicator is adequate for urban distribution systems.
	Op28	Real losses per mains length (l/km/day when system is pressurised) Real losses, expressed in terms of the average daily volume lost per mains length. This indicator is adequate for bulk supply and low service connection distribution systems.

3rd Edition (2017) of *Performance Indicators for Water Supply Systems*.

The IWA PI set related to operational water losses (3 of 3)

Indicator	Sub-indicator	Definition
Op29		Infrastructure leakage index (-) Ratio between the actual real losses and an estimate of the minimum real losses that could be technically achieved for the system operating pressure, average service connection length and service connection density.

- Current version of the PI set is basically the same as the first one (1st Edition, 2000)
  - Precise definitions have received a number of minor changes and refinements

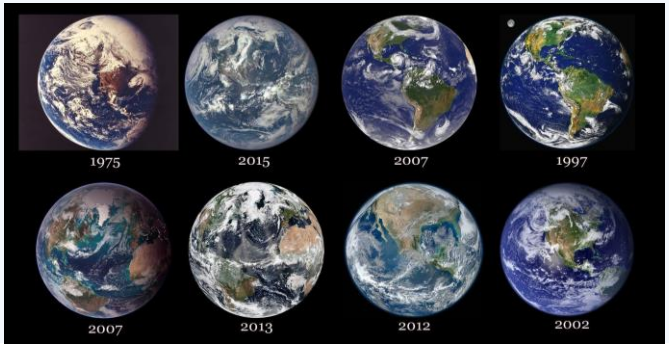
3rd Edition (2017) of *Performance Indicators for Water Supply Systems*.

% of System Input Volume isn't an operational water losses PI

- % of System Input Volume (SIV) and % of Water Supplied (WS) are not/never agreed as operational water losses PIs
  - Not in the 1st (2000), 2nd (2006) nor 3rd (2017) Edition of *Performance Indicators for Water Supply Systems*
  - Not in the 4th Edition (2016) of AWWA Manual M36 *Water Audits and Loss Control Programs*
- Statement PI 2017 Conference in Vienna, Austria on May 15-17, 2017: *"Everyone knows %s of SIV must not be used for target-setting and/or making technical comparisons."*
- Nevertheless, unfortunately these volumetric % PIs are being used, and this presentation intends to reinforce earlier messages that this must be stopped

Appreciation operational water losses PIs

- Need for Fit for Purpose PIs is unchanged; EU Reference document (© EU, 2015)
- Strengths and weaknesses of PIs have become more clear over the last 17 years
- An increasing number of national organisations, countries, water utilities and leading water professionals have decided on moving away from volumetric percentage PIs



NASA pictures of the Earth from the Moon; the Earth didn't change, our view on it changes.

‘Fit for Purpose’ water losses PIs

OBJECTIVE	GOOD PRACTICE PERFORMANCE INDICATOR FOR LEAKAGE, FIT FOR PURPOSE						
	Volume per year	litres/ service connection	m^3/km mains	litres/ billed property	% of System Input Volume	% of Water Supplied	Infrastructure Leakage Index, with Pressure
SET TARGETS AND TRACK PERFORMANCE, FOR AN INDIVIDUAL SYSTEM	YES, for large systems	YES*	YES*	YES (UK)	NO	NO	Only if all justifiable pressure management completed
TECHNICAL PERFORMANCE COMPARISONS OF DIFFERENT SYSTEMS	NO	NO	NO	NO	NO	NO	YES
DRAW GENERAL CONCLUSIONS FROM SINGLE OR MULTIPLE SYSTEMS	NO	NO	NO	NO	NO	NO	YES, together with other context factors
* Choose services connection density > 20/km; if not, choose mains; or base choice on country custom and practice							

Summary of recommendations in EU Reference document Good Practices on Leakage Management (© EU, 2015)

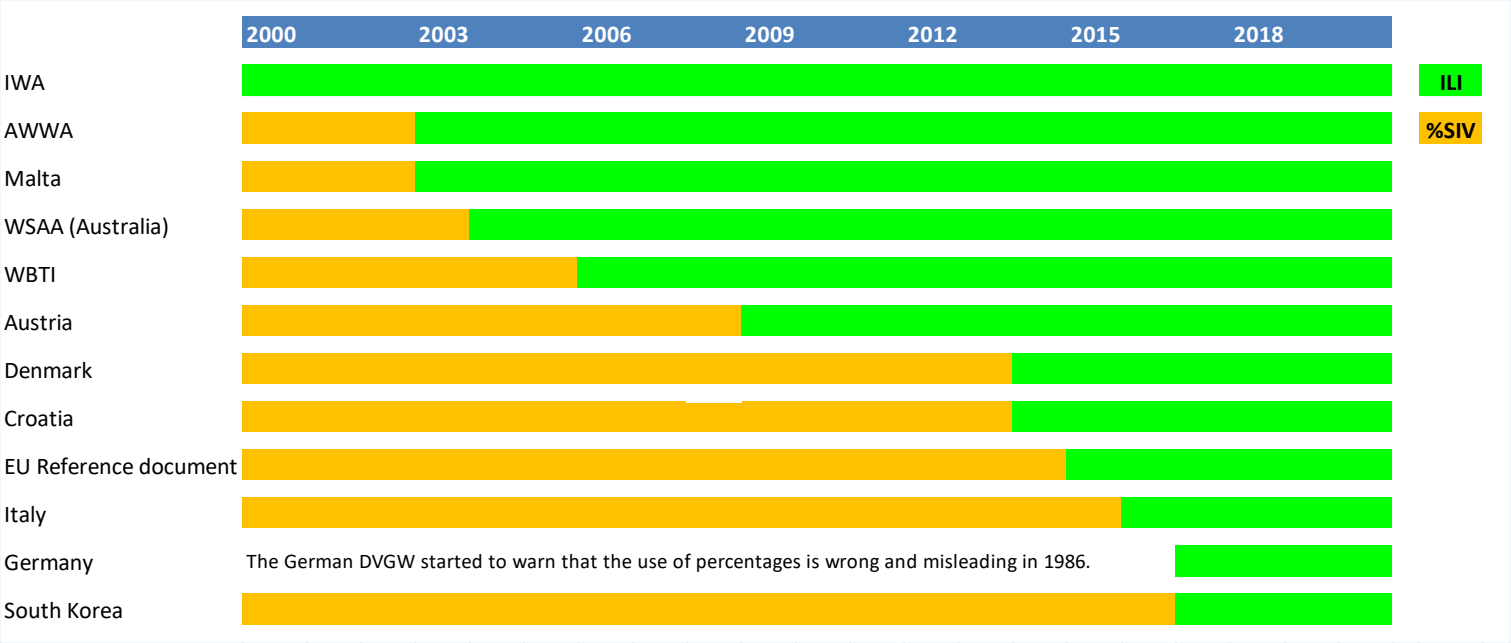
Context matters!

Does the Performance Indicator make allowance for:	Performance Indicator for Real (Physical) Losses				
	% of System Input Volume	m3/km mains/day wsp*	Litres/service connection/ day wsp*	Litres/conn/day /metre of pressure wsp*	Infrastructure Leakage Index ILI (incl. UARL)
% of time pressurised?	No	Yes	Yes	Yes	Yes
water exported?	No	Yes	Yes	Yes	Yes
length of mains?	No	Yes	No	No	Yes
number of connections?	No	No	Yes	Yes	Yes
average pressure?	No	No	No	Yes	Yes
connections/km mains ?	No	No	No	No	Yes
length of services ?	No	No	No	No	Yes
how low could you go?	No	No	No	No	Yes**
* when system pressurised		** Unavoidable Annual Real Losses UARL			

World-wide supported conclusions

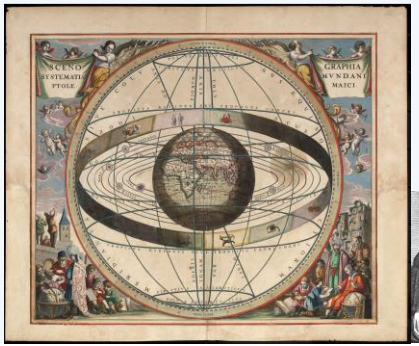
- Volumetric PIs are good for target-setting and tracking progress
- Litres/connection/day/metre of pressure also allows for differences in pressure
- The ILI is designed for technical performance comparisons between systems
- % of System Input Volume just doesn't work:
  - strongly influenced by changes and differences in consumption per connection – variables which may vary substantially from one year to another, not under control of the undertaking
  - does not make allowance for any system-specific key factors (agreed at PI 2017 Conference)
  - gives misleading perspective of true performance

National organizations and countries adopting the ILI

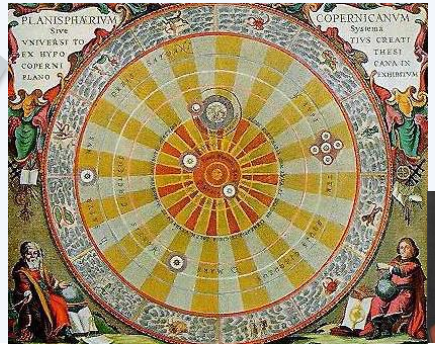


Professionals abandon Percentages of System Input Volume

- Initiative for voluntary registration to PaP from December 27th 2016
- Now (July 5th 2017) already 124 supporters from 22 countries
- PaP supporters cease to support the use of % of SIV or % of Water Supplied as PIs
- PaP supporters professionally use more appropriate and meaningful performance



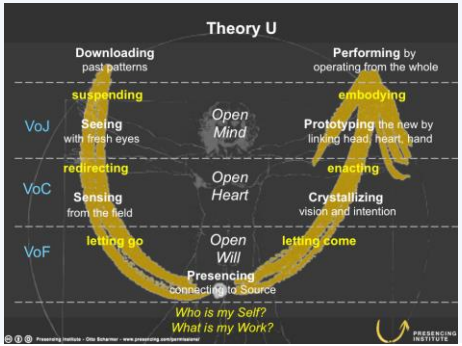
Claudius Ptolemaeus



Nicolaas Copernicus

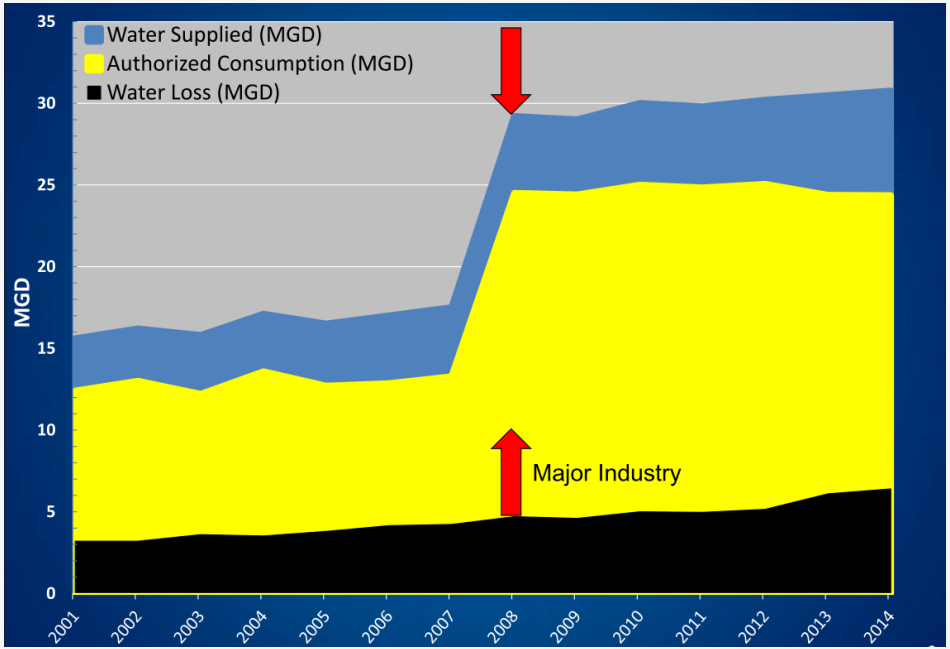
Why do large numbers of professionals support PaP?

- It is difficult to let the past go, but need to recognise and act when change is overdue!
- Volumetric % PIs are easy to calculate and disseminate, but too frequently misleading
- The more appropriate and meaningful PIs indeed require some background and experience in the world of water loss management



C. Otto Scharner, Leading from the Future as it Emerges, San Francisco, 2009

Simulated example I (1 of 4)

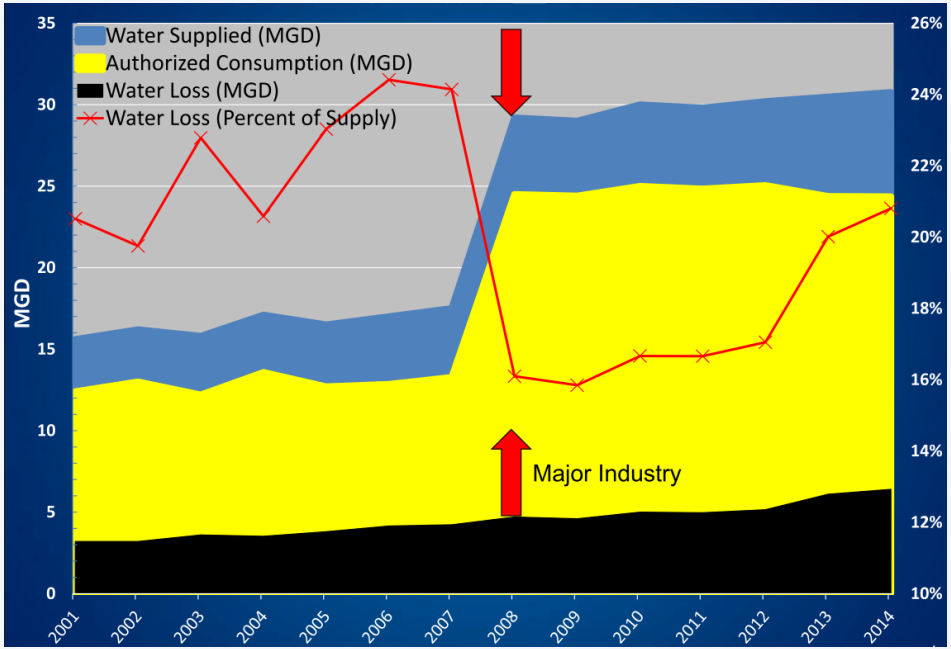


Water Supplied, Authorized Consumption and Water Loss in Million Gallons per Day:

- Utility has no Water Loss Control program in place
- Steadily rising Water Losses over 13 years; doubled from 3 to 6 MGD
- A Major Industry moved to the City so Authorized Consumption has increased

Will Jernigan, P.E., Cavanaugh, NAWL Conference 2015 Atlanta

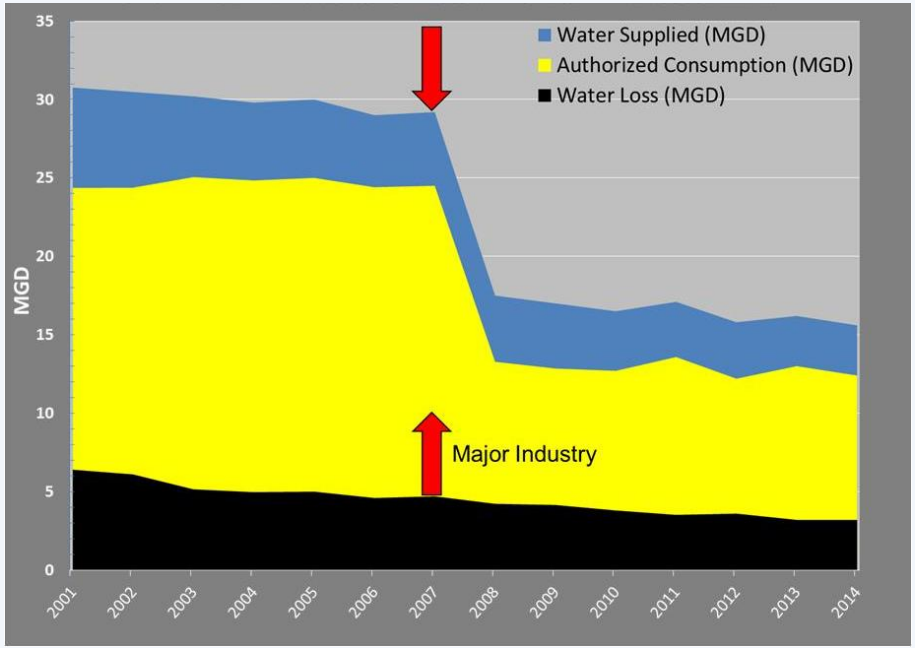
Simulated example I (2 of 4)



Water Supplied and Authorized Consumption in MGD; Water Loss in MGD and by % of Water Supplied:

- Water Loss as a % of Water Supplied is not an indicator of performance
- It seems our performance in volumetric % drastically improved when the Major Industry came to the City → misleading
- Performance 2014 seems similar as 2001 → misleading

Simulated example II (3 of 4)

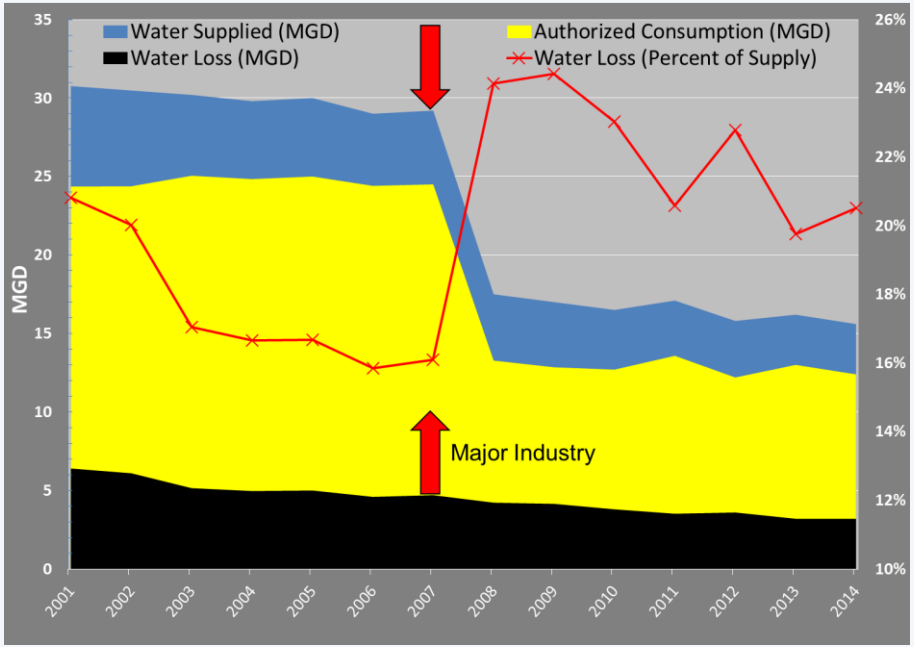


Water Supplied, Authorized Consumption and Water Loss in MGD:

- Comprehensive Water Loss Control program in place
- Steady reductions in total Water Loss over 13 years from 6 to 3 MGD
- Our Major Industry stays in the City but changes to Treated Effluent

Will Jernigan, P.E., Cavanaugh, NAWL Conference 2015 Atlanta

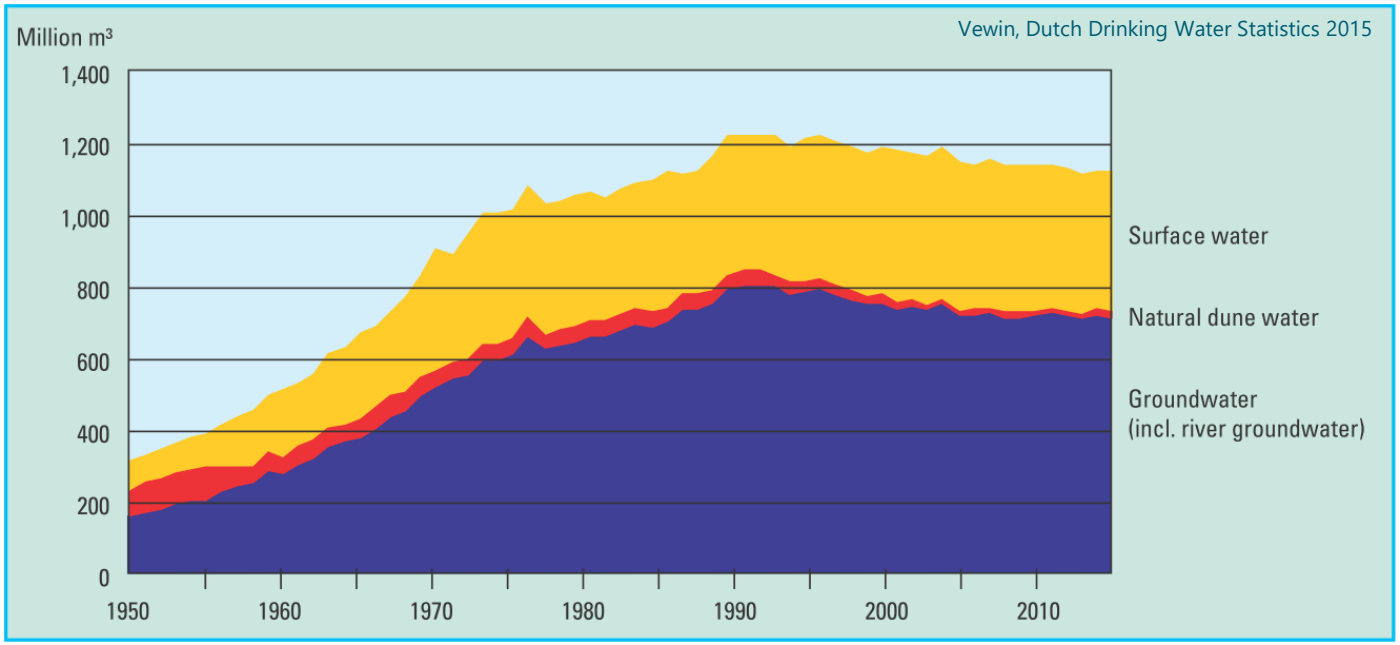
Simulated example II (4 of 4)



Water Supplied and Authorized Consumption in MGD; Water Loss in MGD and by % of Water Supplied:

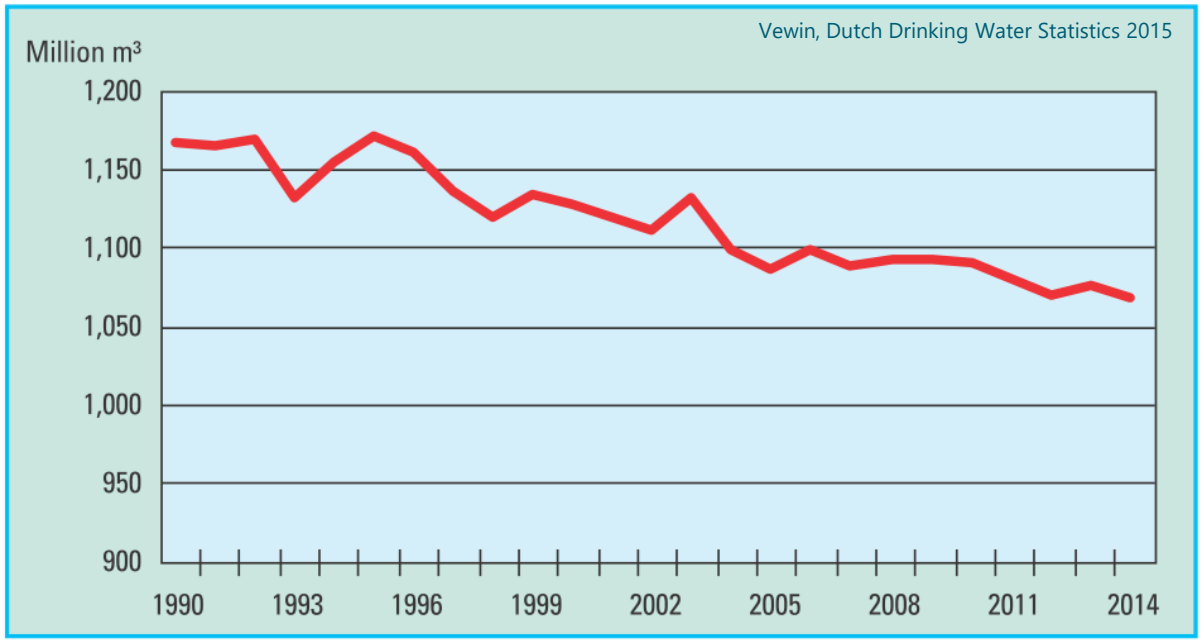
- Water Loss as a % of Water Supplied is not an indicator of performance
- It seems like our performance in volumetric % today is the same as 13 years ago → misleading

Influences of water conservation and efficiency saving (1 of 3)



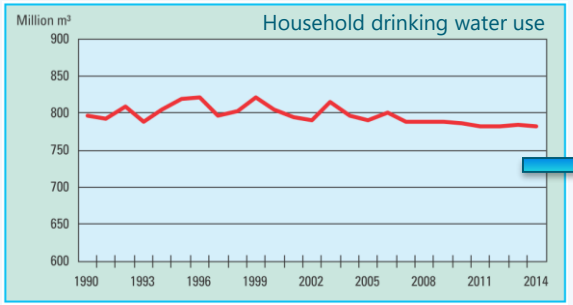
- Dutch water industry performs excellent/efficient
- Low per capita consumption due to water savings
- Low industrial consumption due to water reuse and substitution of drinking water by other water

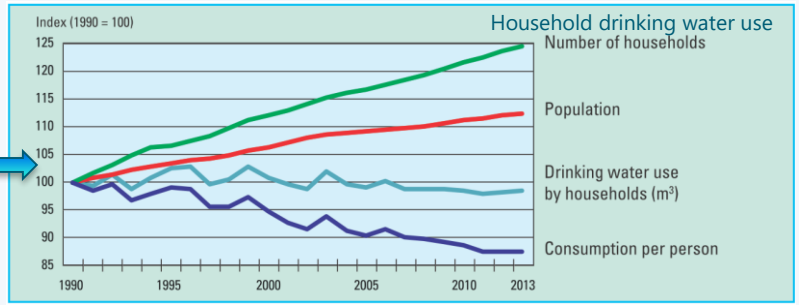
Influences of water conservation and efficiency saving (2 of 3)



- Dutch drinking water sales
- 1,160 Mm^3 in 1990-1995
- Since then a decrease of approx. 100 Mm^3 and ongoing downward trend
- Periods of extreme heat and/or dry weather in years 2003 and 2006

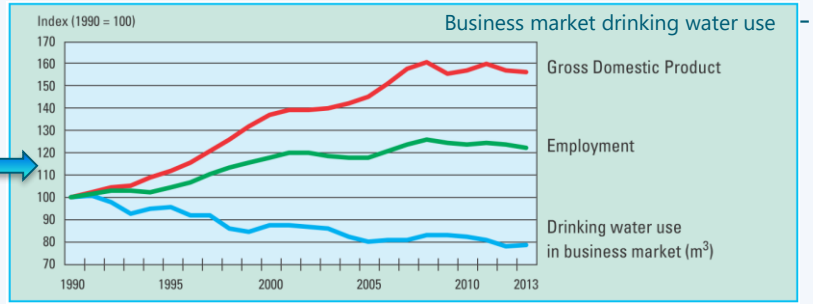
Influences of water conservation and efficiency saving (3 of 3)





- Considerable decline in per capita consumption; growth of population
- Household use only slightly decreased

Vewin, Dutch Drinking Water Statistics 2015



- Considerable decline in business market use despite a growing economy and higher employment level

Just a few real examples of weaknesses of volumetric % PIs

Examples of failure to track progress:

- Zagreb, Croatia – a water utility experience
- Manila, Philippines – a Miya project
- iLembe District Municipality, South Africa – a JOAT Consulting (Pty) Ltd project
- Philadelphia Water Department, USA – a water utility experience

Example of failure for making comparisons of performance:

- DANVA Water in figures 2015 – process benchmarking of water utilities also on ILI

Zagreb, Croatia (1 of 1)

- Utility with high leakage
- Introduced district metering and pressure management in 2012
- In 2013 significant reductions in annual volumes were achieved
- Good work undertaken in the field, but not according to performance judged on change in % of SIV

Water Balance Annual Volumes expressed in Million cubic metres (Mm3)					
Year	System Input Volume	Revenu Water	Non-Revenu Water	Apparent Losses	Real Losses
	Mm3	Mm3	Mm3	Mm3	Mm3
2012	120,7	49,4	71,3	2,0	69,3
2013	114,1	47,3	66,8	1,9	64,9
Change (2013-2012)	-6,6	-2,1	-4,5	-0,1	-4,4
% Change	-5,5%	-4,3%	-6,3%	-5,0%	-6,3%

Water Balance Annual Volumes expressed as & of System Input Volume					
Year	System Input Volume	Revenu Water	Non-Revenu Water	Apparent Losses	Real Losses
	% of SIV	% of SIV	% of SIV	% of SIV	% of SIV
2012	100,0%	40,9%	59,1%	1,7%	57,4%
2013	100,0%	41,5%	58,5%	1,7%	56,9%
% Change	0,0%	0,5%	-0,5%	0,0%	-0,5%

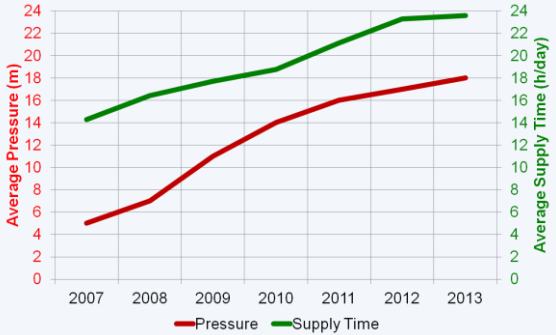
Always a Zero-Sum calculation: one +X%, the other –X%, or both 0%

Manila, Philippines (1 of 3)

- Miya partnered with Maynilad Water Services on a NRW reduction project between 2008 and 2014
- At the beginning of the project NRW was 1,580 million litres/day, three million people could not be connected and supplied, and millions of others suffered from intermittent supply, extremely low pressures and poor water quality
- Project goal was to build NRW management capacity, establish a NRW management system, re-structure and improve the water distribution network, and reduce physical and commercial losses to enable supply to the entire population in the service area

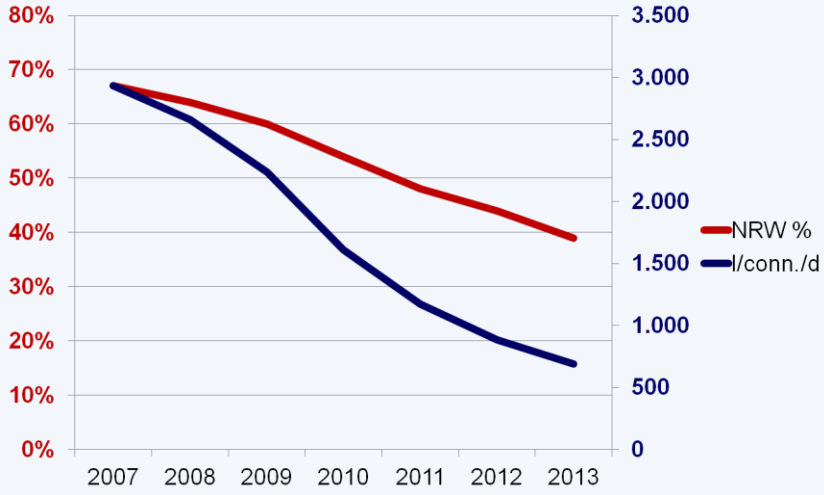
Manila, Philippines (2 of 3)

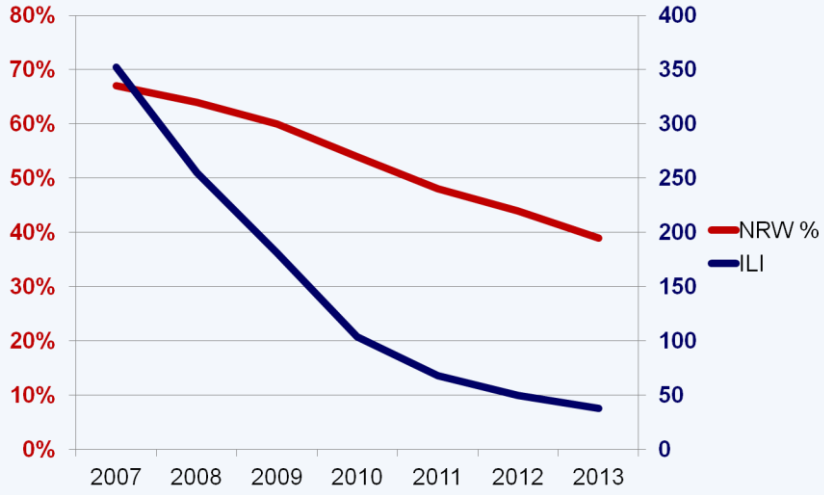
- Results:
  - NRW reduced from 1,580 to 650 million litres/day
  - Number of customers increased from 700,000 to 1,160,000
  - Tremendously improved level of service
  - 1,500 DMAs established, 1,500 km of pipelines replaced
  - 277,000 leaks detected and repaired
  - Maynilad's net income tripled



- Additional revenues during this seven year period already exceeded the investments

Manila, Philippines (3 of 3)

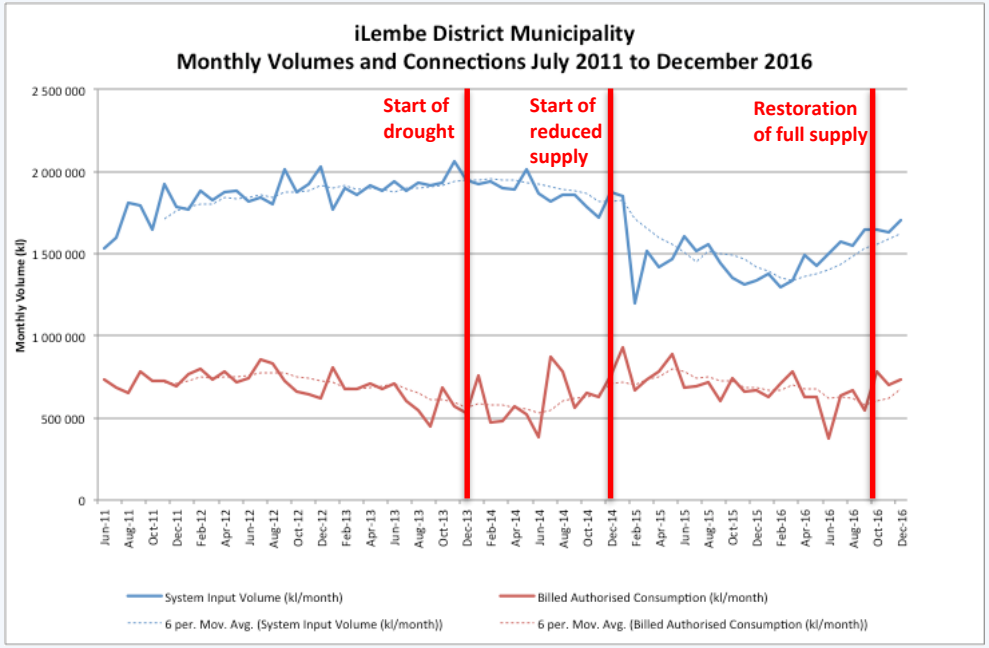




iLembe District Municipality, South Africa (1 of 3)

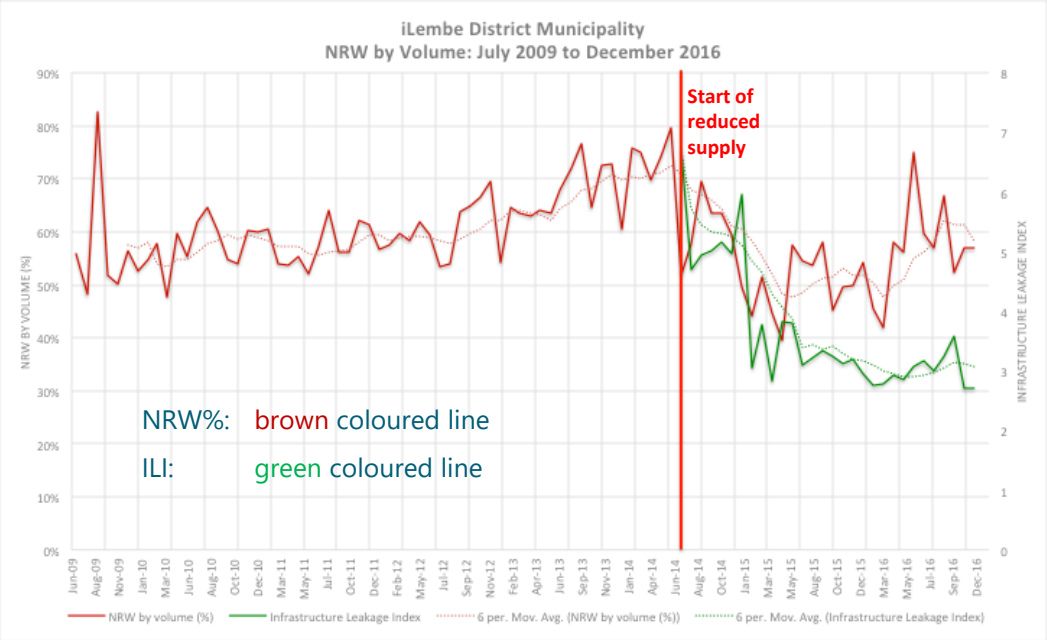
- iLembe District Municipality serves approx. 630,000 people in a predominantly rural / peri-urban service area with holiday influx
- Experienced severe drought which commenced in circa 2013 and led to intermittent / reduced supply from December 2014
- Drastic leakage reduction and water conservation intervention was very quickly rolled out to meet reduced supply → restoration of full supply in October 2016
- The South African Government's Department of Water and Sanitation requires quarterly reporting in NRW% and either rewards or penalises on this KPI

iLembe District Municipality, South Africa (2 of 3)



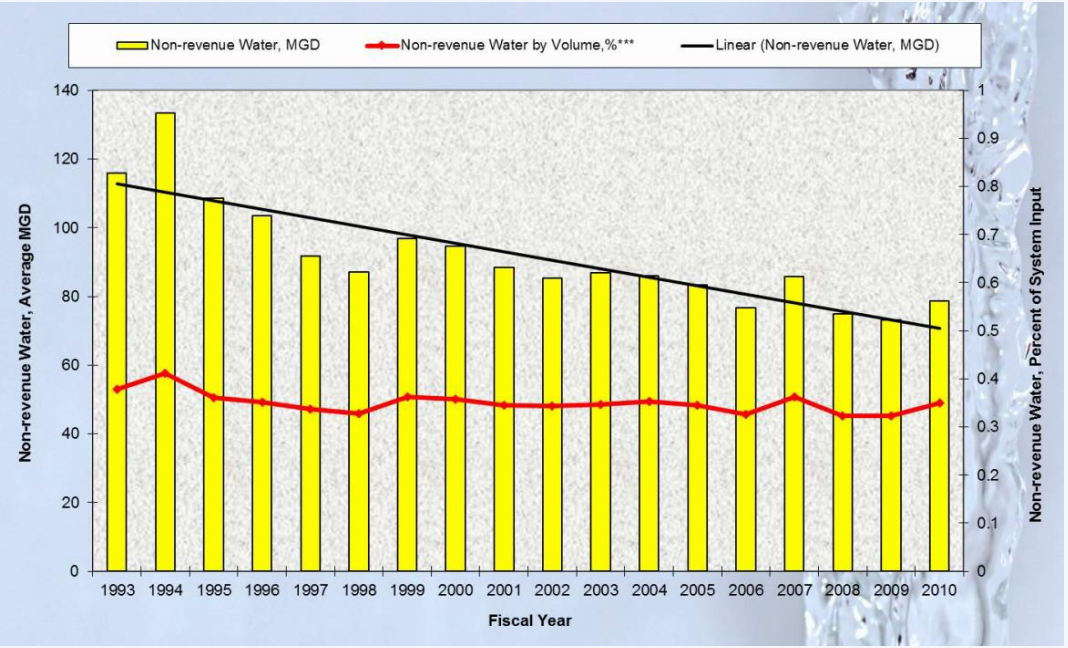
- Start of drought December 2013
- Intermittent / reduced supply from December 2014
- Restoration of full supply from October 2016

iLembe District Municipality, South Africa (3 of 3)



- During this drought response, NRW% did not reflect the good work undertaken in the field and in fact showed the opposite
- Investments were initially made on NRW% but investment parameters were changed to align more with ILI

Philadelphia Water Department, USA (1 of 1)

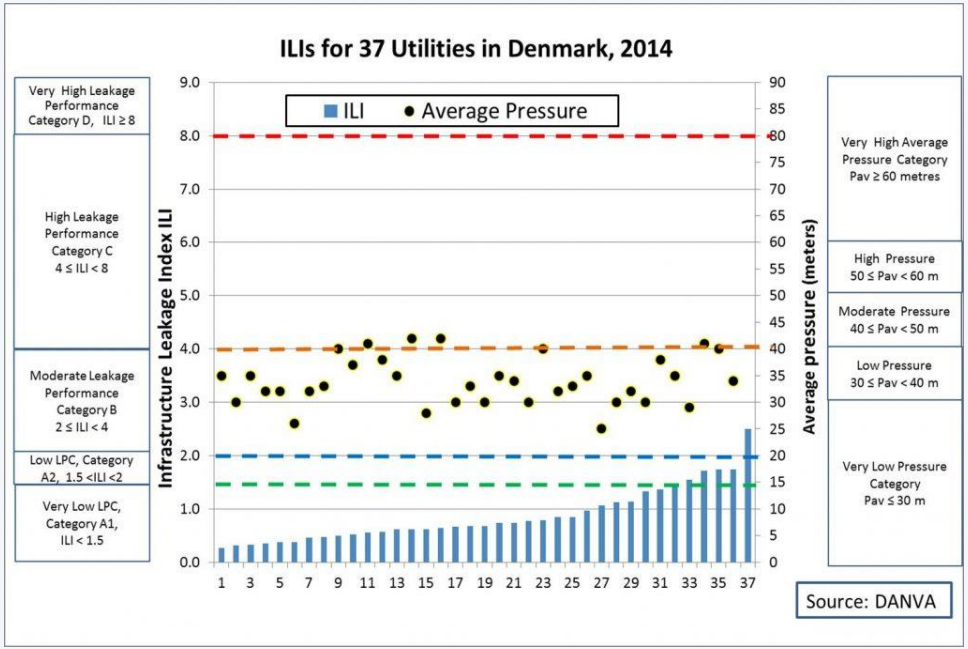


- Pioneer in managing NRW
- Longest running formal Water Loss Control program in North America
- Smart metering since 2000
- Successful reduction of water losses from 120 to 70 MGD
- But performance as NRW% has stayed about the same

DANVA figures 2014, Denmark (1 of 5)

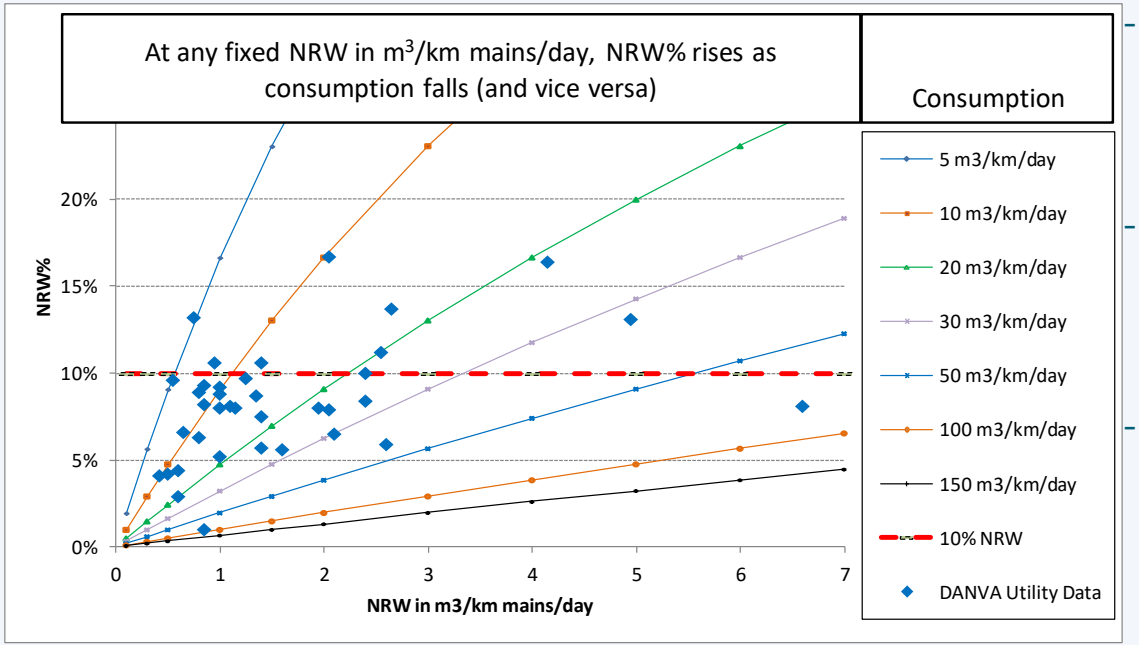
- Danish water industry has very low loss of water in most of its pipeline network
- Groundwater levels are falling; water is expensive, and if NRW > 10% Utilities pay additional tax of 6.13 DKK/m^3 (approx. 0.713 GBP/m^3 or 0.824 EUR/m^3 or 0.92 USD/m^3)
- Per capita consumption reduced to around 100 litres/head/day
- Water loss volumes much reduced in recent years
- Weighted average NRW of 48 Utilities as % of SIV was 8.1 in 2014
- NRW in m^3/km mains/day ranges from 0.2 to 6.6
- ILI of 27 out of 37 Utilities in 2014 was ≤ 1.0, highest 2.5

DANVA figures 2014, Denmark (2 of 5)



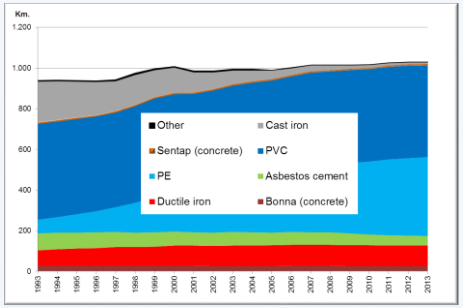
- Most Danish Utilities make very little or no allowance for Unbilled Authorised Consumption and Apparent Losses so Real Losses almost equal to NRW
- Predominantly operation at very low to low average pressures
- ILI of 27 out of 37 Utilities was ≤ 1.0; 36 Utilities are in very low or low Leakage Performance Categories (LPC)

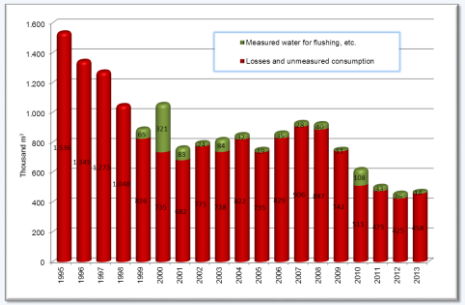
DANVA figures 2014, Denmark (3 of 5)

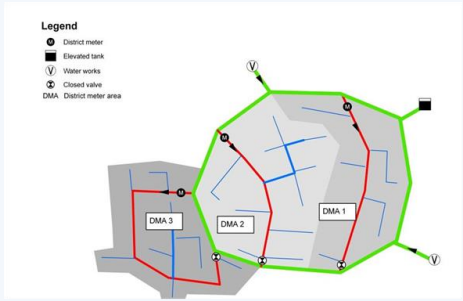


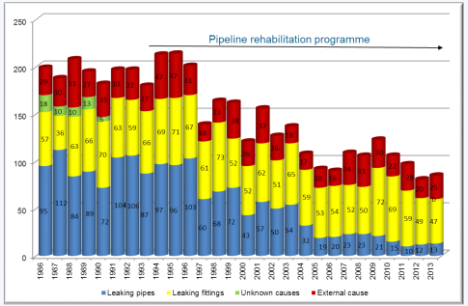
- Consumption strongly influences NRW volume expressed as a percentage
- NRW% of 28 out of 37 Utilities was < 10%; 24 out of these 28 Utilities already have ILI < 1.0
- How to deal with any further decline in consumption?

VandCenter Syd (VCS), Denmark (4 of 5)









- Pipeline rehabilitation program since 1993
- Successful implementation of district zoning and pressure management; average operation pressure 30 m
- Significant reduction of water losses from 1.54 Mm^3 (1995) to 0.46 Mm^3 (2013)
- Significant reduction of mains burst from 96 (1995) to 13 (2013)
- ILI = 0.7 and 1.40 m^3/km mains/day

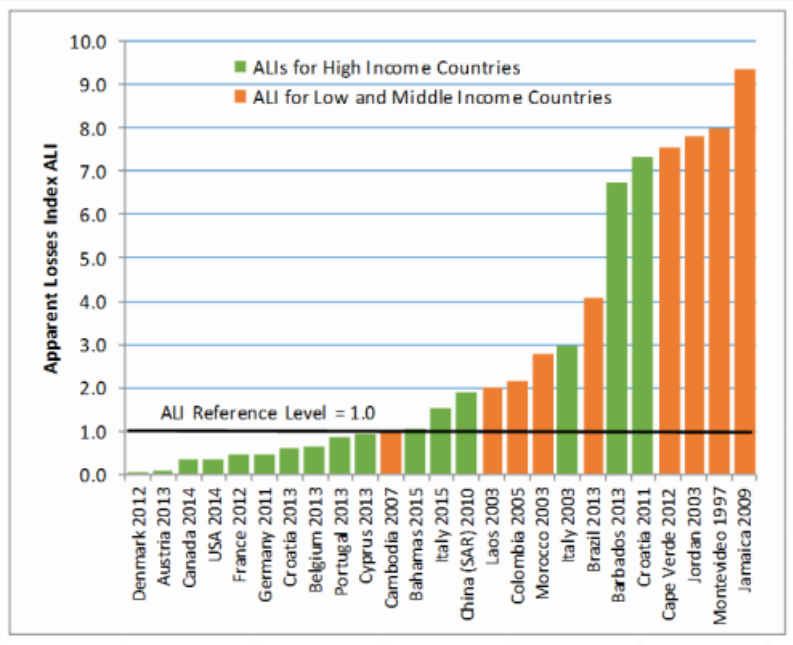
EU Reference document, Danish case study VCS Odense (2014).

DANVA figures 2014, Denmark (5 of 5)

- Context matters:
  - Ranking Utilities on water loss PIs is not that important
  - The ILI helps to identify likely priorities for action to reduce leak flow rates and mains and services bursts
  - NRW% is "unfair" to peri-urban / rural Utilities, m^3/km mains/day is "unfair" to urban Utilities (with service connection density >> 20/km)
- Monetary penalties on NRW% are "unfair" to all Utilities
  - "Sword of Damocles" when water consumption further declines
  - Regulators and Utilities should use 'Fit for Purpose' water losses PIs

Utility	NRW%	m3/km mains/d	ILI
Aarhus	5,6%	1,60	0,6
Aarlborg	8,4%	2,40	1,5
Arwos	10,6%	1,40	1,0
Assens	8,0%	1,15	0,5
Bornholm	13,2%	0,75	0,5
Esjberg	5,2%	1,00	0,6
FFV (Faaborg-Midtfyn)	9,3%	0,85	0,5
Fredensborg	7,5%	1,40	0,6
Frederiksberg	1,0%	0,85	0,3
Frederikshavn	8,8%	1,00	0,4
Frederikssund	6,3%	0,80	0,1
Gentofte	13,1%	4,95	1,6
Gladsaxe	5,9%	2,60	1,1
Grindsted	9,7%	1,25	0,7
Halsnaes	16,7%	2,05	1,1
Herning	8,1%	1,10	0,6
Hjorring	4,1%	0,42	0,4
HOFOR Copenhagen	8,1%	6,60	2,5
Holbaek	11,2%	2,55	1,4
Horsholm	7,9%	2,05	0,7
Kalundborg	6,5%	2,10	1,3
Koge	13,7%	2,65	1,4
Lolland	9,6%	0,55	0,4
Provas	9,2%	1,00	0,8
Roskilde	8,0%	1,95	0,9
Rudersal	16,4%	4,15	1,6
Silkeborg	4,4%	0,60	0,3
Skive	8,2%	0,85	0,7
Sonderberg	8,7%	1,35	0,6
Svendbord	8,0%	1,00	0,6
Thisted	10,6%	0,95	0,8
Trefor	10,0%	2,40	1,2
Vandcenter Syd	5,7%	1,40	0,7
Varde	8,9%	0,80	0,6
Verdo	2,9%	0,60	0,3
Vestfors	6,6%	0,65	0,4
Viborg	4,2%	0,50	0,3

The non-dimensional Apparent Losses Index



- Developed in 2011 to complement the ILI
- The authors of the *Guidance Notes on Apparent Losses and Water Loss Reduction Planning* (15th September 2016) are seeking additional validated ALIs for ongoing further analysis
  - Please contact authors Michel Vermersch and/or Alex Rizzo by e-mail

Let the past go!

- Move away from volumetric percentage PIs and move towards using:
  - the Infrastructure Leakage Index, ILI (Op29)
  - "volume/connection/day" or "volume/km/day" (Op23/Op27 or Op24/Op28)
  - over the medium-term, replace Op25 for Apparent Losses with the Apparent Losses Index (ALI) and review Op26
- Professionally use:
  - the ILI for technical performance comparisons of water supply systems
  - "volume/connection/day" or "volume/km/day" for target-setting and tracking progress
- Support the PaP initiative

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