
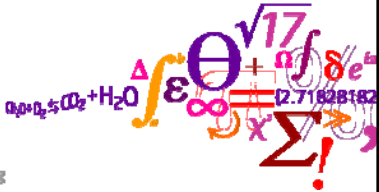


Technical University of Denmark 


## Future urban water supply when the groundwater resource is under pressure

Hans-Jørgen Albrechtsen  
Martin Rygaard  
Philip J. Binning

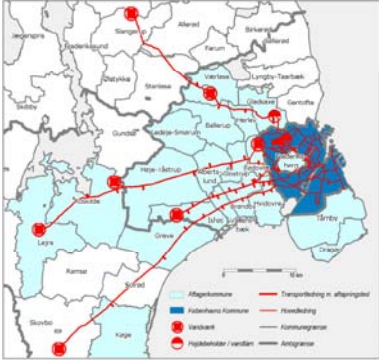
4th Annual Meeting of DWRP10  
January 28-29, 2010  
GEUS



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## KE Abstraction licenses



- ◆ – many will expire in 2010
- ◆ EU Water Framework Directive

KE, 2005

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## PPP –Public-Private-Partnership KE – DTU Environment

- ◆ Frame collaboration agreement for 6 years
  - ◆ umbrella for ad hoc agreements
- ◆ Regular meetings in board – general information exchange
- ◆ Ke
  - ◆ Technological preparedness / Decision support
- ◆ DTU Env
  - ◆ Knowledge base / Bonding to reality

**Output:**

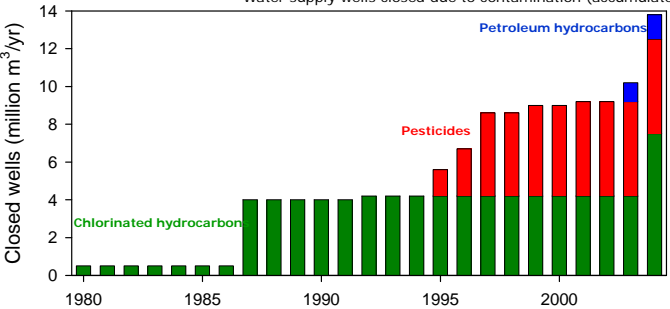
- ◆ Development / strategy
- ◆ Input to 'VVM-redegørelse' and alternatives
- ◆ Student projects
- ◆ Case study in a PhD-study
- ◆ Business PhD
- ◆ 5 reports, 1 book IWA
- ◆ National and international presentations and publications

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## Contamination

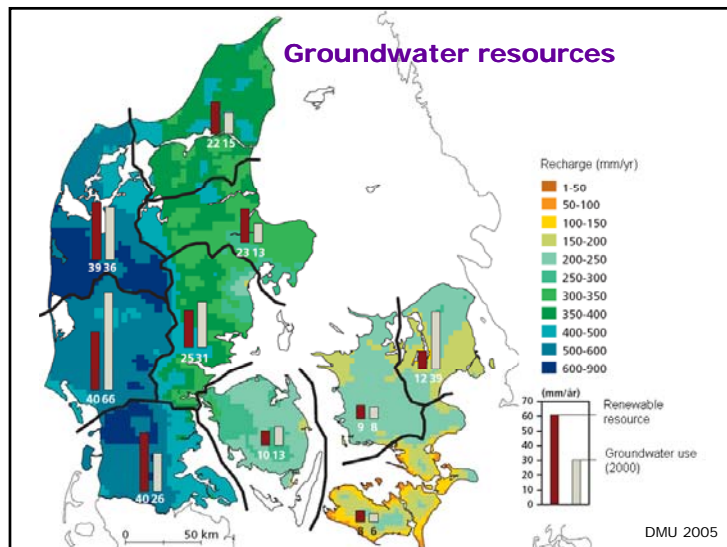
Water supply wells closed due to contamination (accumulated)



Year	Chlorinated hydrocarbon (million m <sup>3</sup> /yr)	Pesticides (million m <sup>3</sup> /yr)	Petroleum hydrocarbons (million m <sup>3</sup> /yr)	Total (million m <sup>3</sup> /yr)
1980	0.5	0	0	0.5
1981	0.5	0	0	0.5
1982	0.5	0	0	0.5
1983	0.5	0	0	0.5
1984	0.5	0	0	0.5
1985	0.5	0	0	0.5
1986	0.5	0	0	0.5
1987	0.5	0	0	0.5
1988	0.5	0	0	0.5
1989	0.5	0	0	0.5
1990	0.5	0	0	0.5
1991	0.5	0	0	0.5
1992	0.5	0	0	0.5
1993	0.5	0	0	0.5
1994	0.5	0	0	0.5
1995	0.5	1.5	0	2.0
1996	0.5	2.5	0	3.0
1997	0.5	3.5	0	4.0
1998	0.5	4.5	0	5.0
1999	0.5	4.5	0	5.0
2000	0.5	4.5	0	5.0
2001	0.5	4.5	0	5.0
2002	0.5	4.5	0	5.0
2003	0.5	4.5	0	5.0
2004	0.5	4.5	0	5.0
2005	0.5	4.5	1.0	6.0

KE, 2005

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### Fremtidens vandbehov

Grundvandsindvindingstilladelser på værksniveau i mio. m<sup>3</sup>/år  
Inkl. 25 % buffer

Værk	Nu	Indv. 2008	Ansøgt
Søndersø	19,0	11,67	13,2
Islevbro	17,2	5,53	9,0
Thorsbro	14,9	7,58	11,09
Marbjerg	4,0	2,63	4,8
Lejre	18,0	6,92	8,31
Slangerup	17,0	8,75	11,1
Regnemark	16,0	12,51	14,65
<b>Samlet</b>	<b>106,1</b>	<b>55,58</b>	<b>72,15</b>

Samarbejde med andre vandforsyninger øger forsynings sikkerheden

Jens Rasmussen, KE


ID Familie møde 22. oktober 2009



### 'Vandplaner'

	Current abstraction	Replacement /Relocation
• Kalundborg	-	-
• Isefjord og Roskilde Fjord	60	13.6
• Øresund	-	0.2
• Køge Bugt	31	24
• Smålandsfarvandet	-	3.1
• Østersøen	-	-


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### 'Vandplaner' winter 2010


- ◆ **Consequences for KE:**
- ◆ Reduce/re-locate abstraction fields for 32 m<sup>3</sup>/yr
  - ◆ Current production: 72 m<sup>3</sup>/yr / (56 m<sup>3</sup>/yr )
- ◆ Costs: 32 mio kr (BLST)
  - ◆ KE: underestimation of costs
  - ◆ + pre-investigations
  - ◆ + VVM
  - ◆ + planning, investment in area
- ◆ Are the conditions and conclusions correct?

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### Drivers for using alternative sources to groundwater

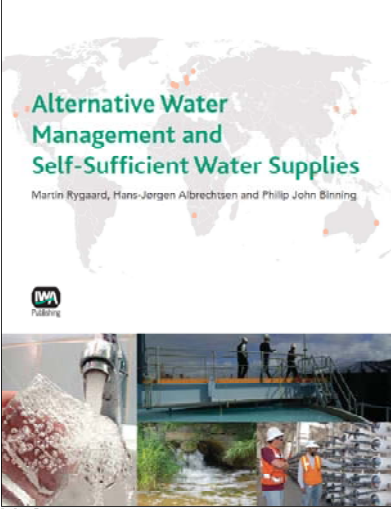
- ◆ Politically decided restrictions in access to groundwater
  - ◆ Maybe now is the time to changes in paradigm – is groundwater too good to be used for drinking water?
- ◆ Climate changes:
  - ◆ Surplus of water from flooding?



Værste oversvømmelser i 800 år i Irland  
22. nov. 2009. DR.dkFoto: BRIAN STEWART © Scanpix

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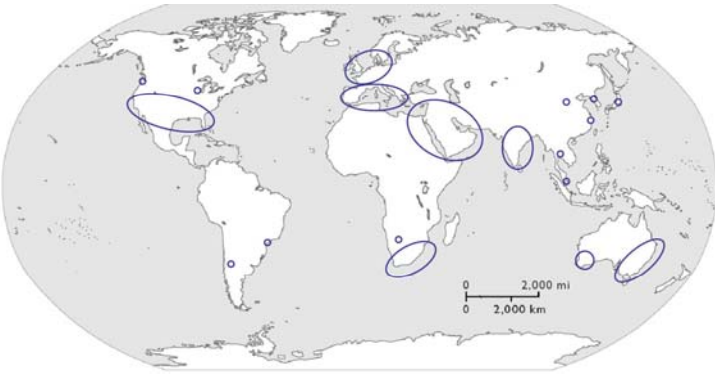
**Alternative Water Management and Self-Sufficient Water Supplies**  
Martin Rygaard, Hans-Jørgen Albrechtsen and Phillip John Blinling

DTU Publishing

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### Cases — 113 from 6 continents



0 2,000 mi  
0 2,000 km

○ Area with several cases listed  
● Single case

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**Five ways to increased self-sufficient water supply**



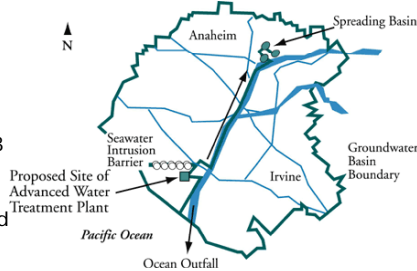
- Water savings & consumer regulation 
- Recycling used water 
- Use of contaminated ground water 
- Desalination brackish /salt resources 
- Rain water 

**B: Recycling**


**Orange County, USA**




- 2.3 mio. inhab., 900 km<sup>2</sup>
- Recycling since 1975 (21 mio. m<sup>3</sup>/yr)
- Since 2007: 97 mio. m<sup>3</sup>/yr
- Infiltration/injection (ARG) in aquifer, abstraction: 333 mio. m<sup>3</sup>/yr
- Water storage
- Approx. 2.5 kr./m<sup>3</sup> recycled water




www.gwrsystem.com




**B: Recycling**




- Independent on climate
- Big volume (KBH ~30 mio. m<sup>3</sup>/yr)
- Use for drinking water: controversial
- Non-potable: Also controversial, needs double piping
- Rapidly growing (EU Water reuse manual)





Orange County recycling, CA, USA




**C: Contaminated groundwater**





- Infiltration - or
- Secondary water supply
  - Contaminated groundwater: Toilet flushing in Millenium Dome, London
  - Lowering the groundwater table next to the Øresundsbron → Boiling water at Amagerværket
  - Small (< 0,5 mio. m<sup>3</sup>/yr)
  - Expensive (>7 kr./m<sup>3</sup>)
  - Few volumes in Copenhagen

### D: Desalination – Perth




Urbane område

Foto: Andrew Bath

- 1,5 mio. inhab.
- Millinium draught
- Desalination of 45 mio. m<sup>3</sup>/år (maybe doubled in few years)
- 4,5 kr./m<sup>3</sup> incl. buying power from windmills
- CO<sub>2</sub>-neutral?
- Information to consumers

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### D: Desalination




Cases (reference year)	Key figures for desalination of seawater
Singapore (2006)	> 40 mio. m <sup>3</sup> /yr (~10 % of consumption) 3-5 kr./m <sup>3</sup> 4 kWh/m <sup>3</sup>
Perth, Australien (CO <sub>2</sub> -off-set, 2006)	45 mio. m <sup>3</sup> /yr (~17 % of consumption) 4,5 kr./m <sup>3</sup> 4 kWh/m <sup>3</sup>
Gold Coast, Australien (2007)	46 mio. m <sup>3</sup> /yr (shared with other municipalities in region) 4 kr./m <sup>3</sup> 5,1 kWh/m (incl. distribution)
London, UK (2010, <10‰ salinitet, CO <sub>2</sub> -neutral?)	51 mio. m <sup>3</sup> /år (capacity 250 mio. t, ~1kWh/m <sup>3</sup> , 40% of time)
Spanien Holland Israel Etc.	

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### D: Desalination







- In examples membran based
- Climate independent – huge water resource
- Can be established in short time (Perth and Gold Coast 18-24 month)
- Low salinity in Øresund → Low energy consumption

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### E: Rainwater




Cases (reference year)	Key figures for rainwater collection
Stenløse Syd, Denmark (2007)	Approx. 25 % of household consumption
Millenium Dome, UK (2000)	13,100 m <sup>3</sup> /yr or 10 % of water consumption in multihall (19 %-vol of toilet-flushing)
Potsdammer Platz, Germany (2006)	Runoff reduced by 75 %
Singapore (2007)	2/3 of the country leads rainwater to reservoirs
Seoul, Korea (2007)	Unknown volume
Gold Coast, Australia (2056)	7,3 mio. m <sup>3</sup> /yr, ~ 8 % of water consumption (29 % in the area of Pimpama-Coomera)



Millenium Dome  
Foto: Manuel/skyscrapercity.com

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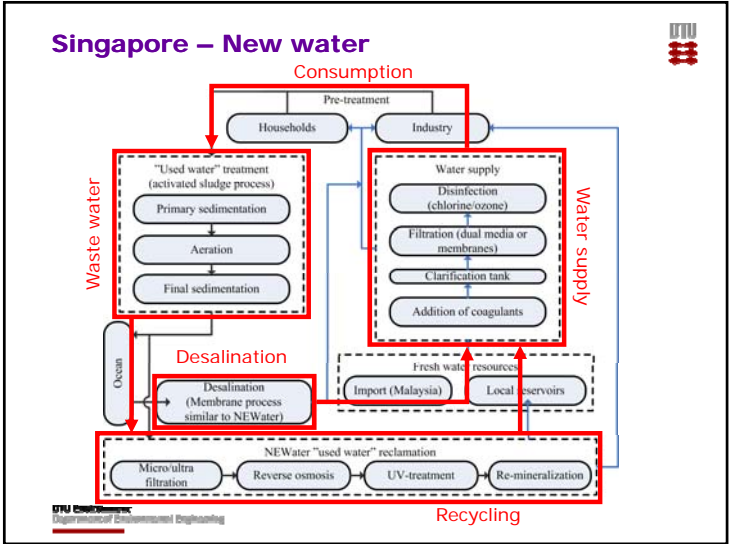
### Stenløse syd



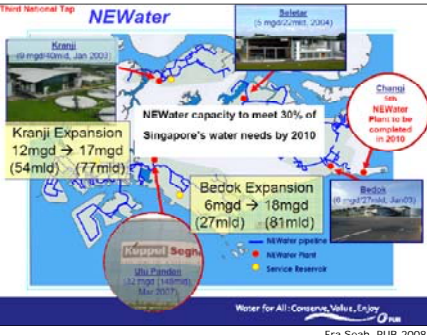
Miljøstyrelsen 2002  
Foto: stenloesyddk

- Mandatory rainwater collection
- Water supply and runoff control (recharge)
- 750 houses expected to save 25 % of householding consumption
- Active policy in ownership to force demands through
- Limited extra costs at new constructions (50.000 kr./house)

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### Singapore – New water



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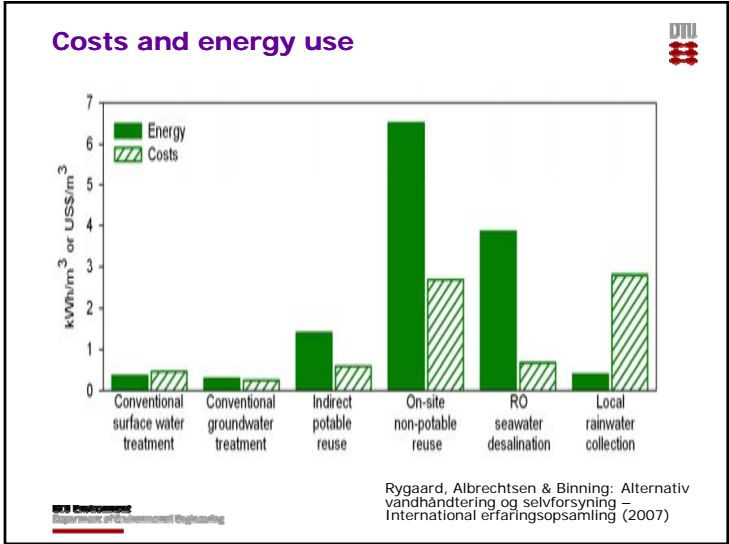
- Efterspørgslen på recirkuleret spildevand større end forventet
- Bedre kvalitet
- Stabil kvalitet

### Singapore – Marine Barrage



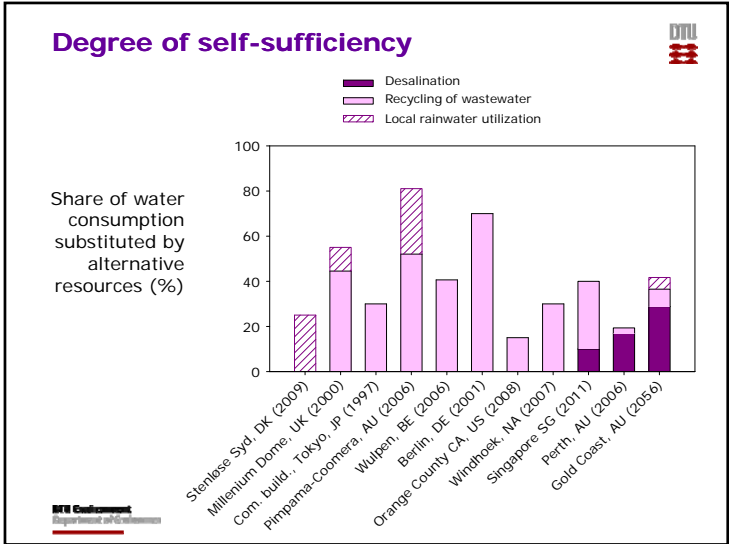
- Tree-in-one:
- Fresh water reservoir
- Storm water buffer
- Recreative area

Fra Seah, PUB 2006



### Five ways to increased self-sufficient water supply

	Back bone	Supplement	Preparedness
Water savings in households		(X)	
Desalination brackish /salt resources	X	X	(X)
Use of contaminated ground water		X	
Recycling for potable use	X	X	
Recycling for non-potable use		X	
Rainwater		X	



### Alternative Water Management and Self-Sufficient Water Supplies

Martin Rygaard, Hans-Jørgen Albrechtsen and Philip John Sinning

Tak!

københavns E