Centre Universitarie d'étude des problemès de l´énergie. Université de Genève

Séminaire "Énergie et Environnement"

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Impacts de la demande: la production d'eau douce

Javier Uche

University of Zaragoza/CIRCE Foundation

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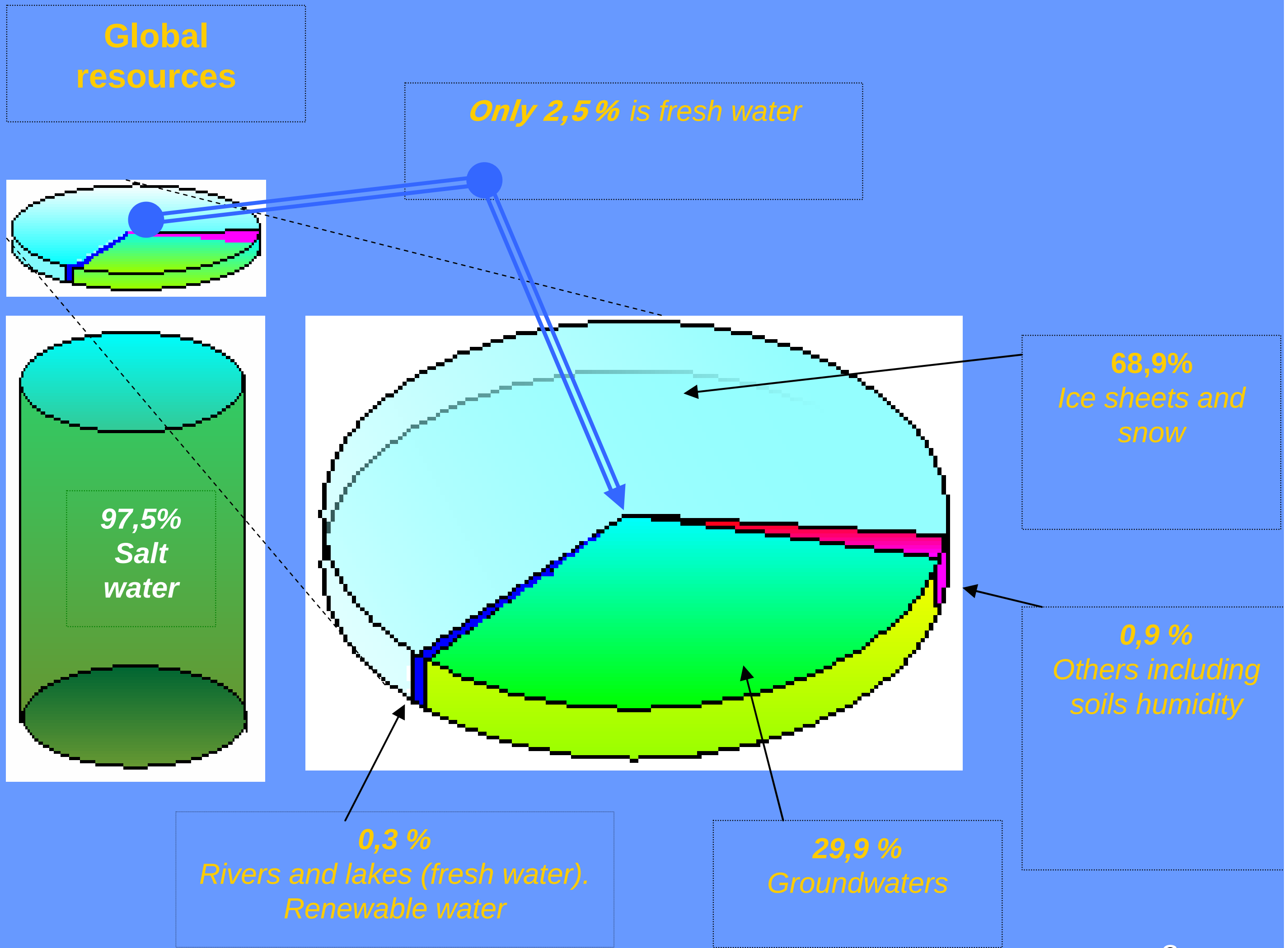
- Conclusions

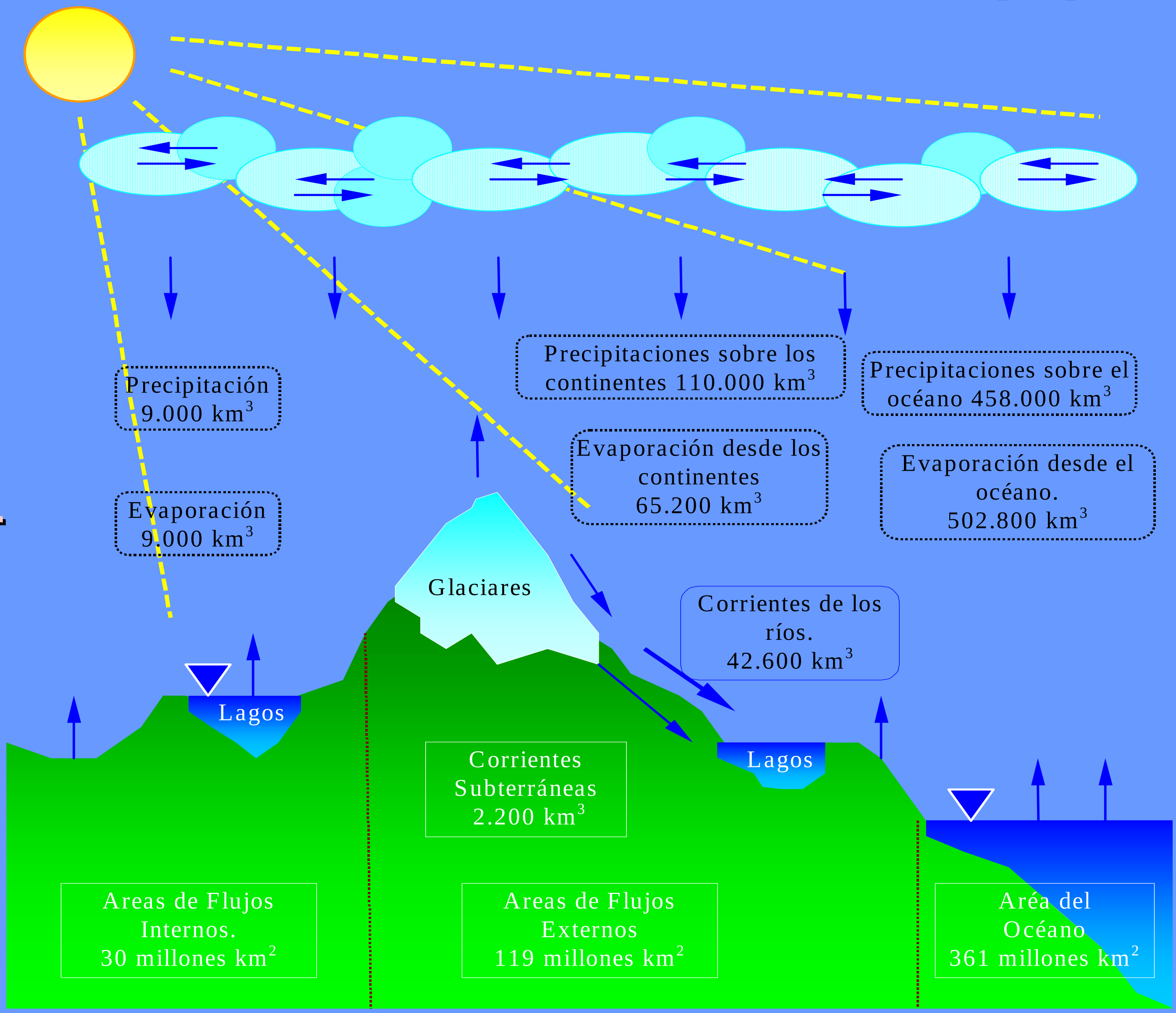
Water problems in the World (1)

- Water reserves are impressive: 1,386 Mkm³
- However, renewable resources are only 42,600 km³/year
- Only 7,000 km³ are really useful



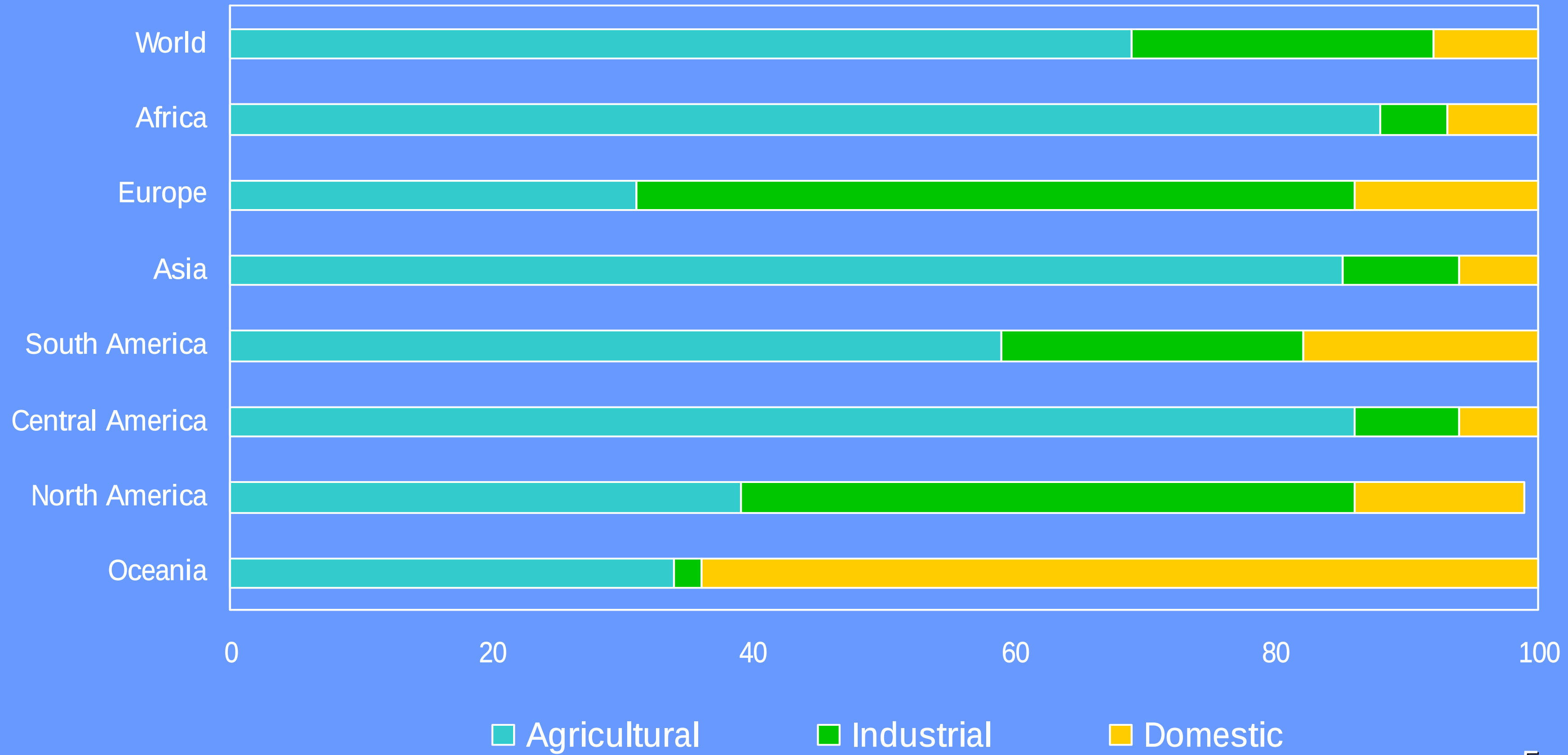
Water problems in the World (2)

- Available water is only a very small part of the water cycle in the Earth



Water problems in the World (3)

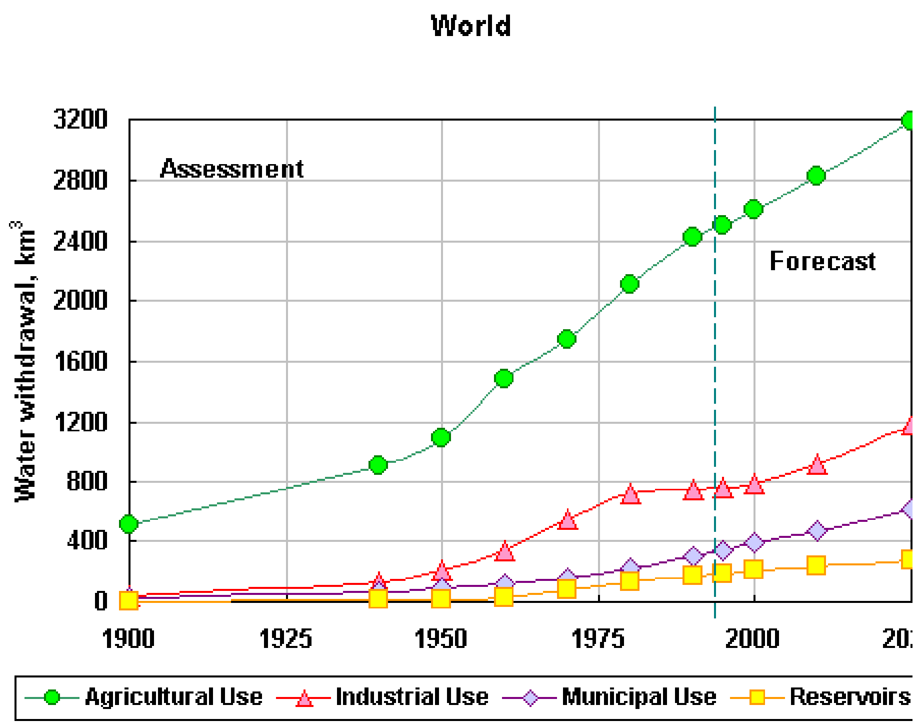
- Water uses are strongly linked to economic level of each area

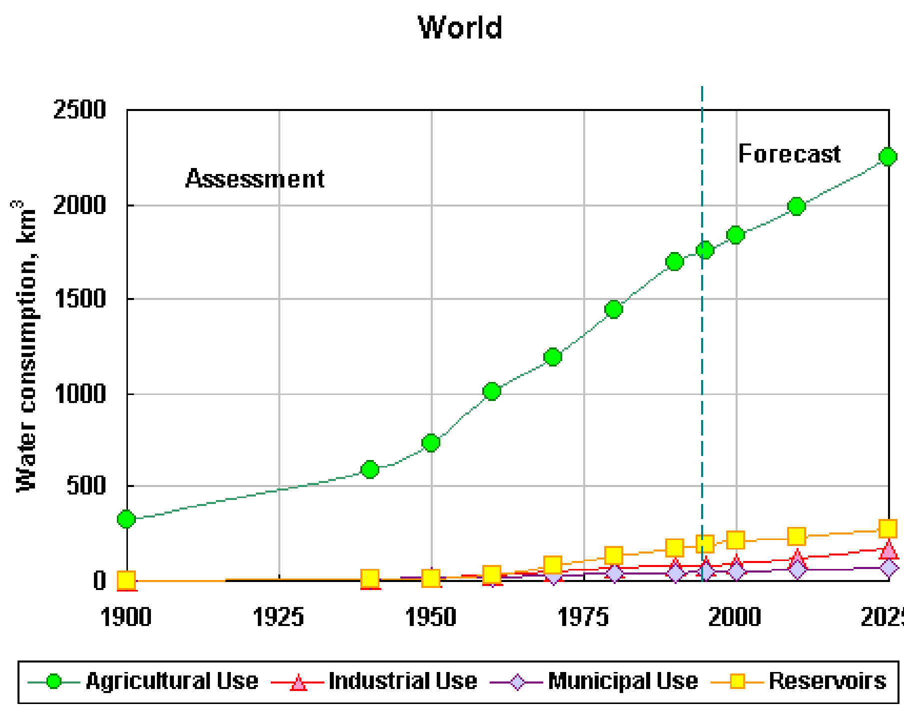


12% of the population consume the 85% of water

Water problems in the World (4)

- Water consumption is increasing more and more every day.





Ratio availability/population

Water problems in the World (5)

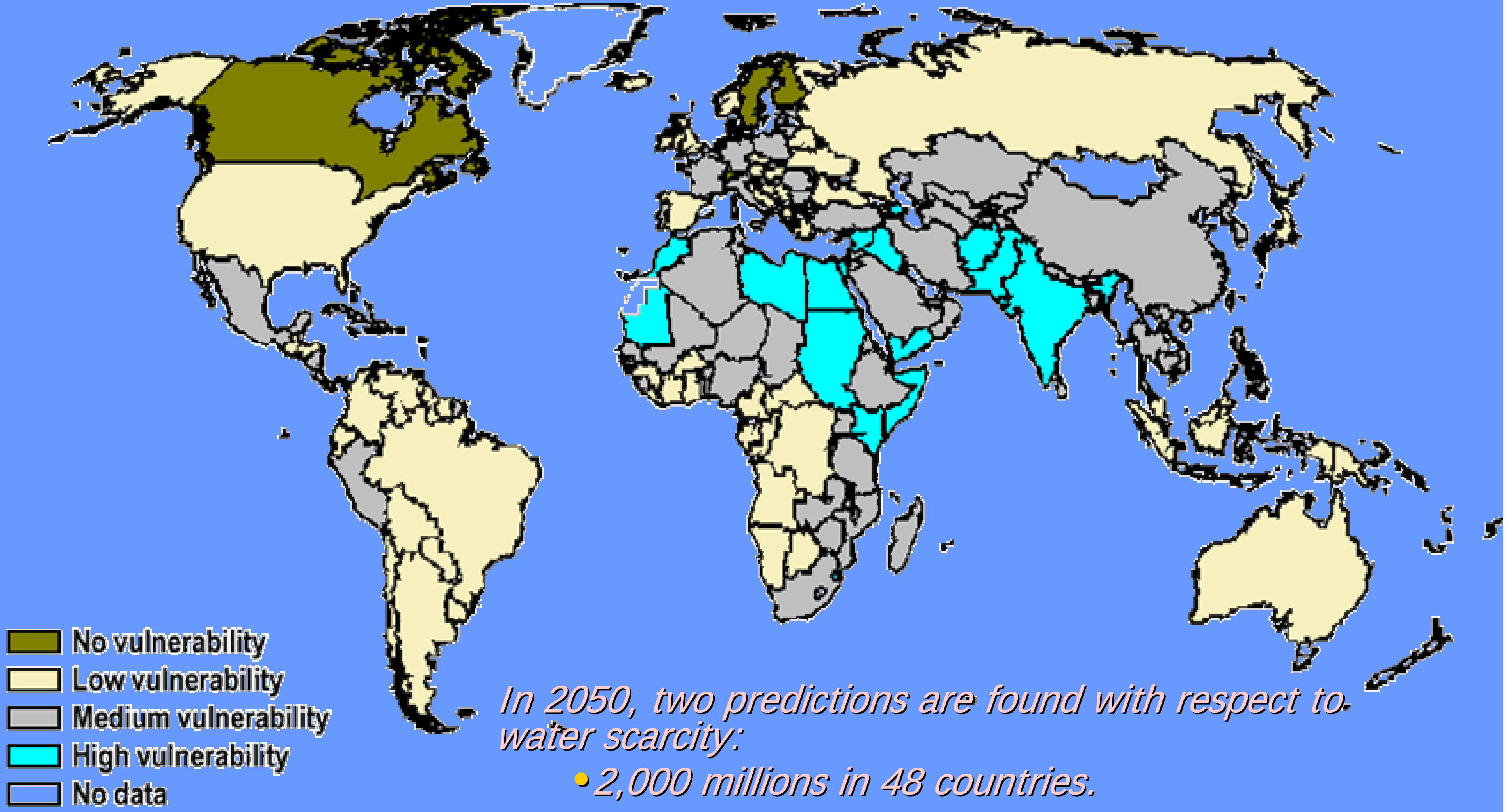
- Water resources are not well distributed

País o continente	Anual (km^3)	Per cápita (m^3/hab)
Germany	96	1.165
Spain	110,3	2.775
France	180	3.065
Eire	47	13.187
Norway	384	87.691
United kingdom	71	1.219
Russia	4.312,7	29.115
Switzerland	42,5	5.802
EUROPE	**6.142,9**	8 / 13
Canada	3.287	120.000
United States	2.930	11.500
NORTH AMERICA	**6.217**	15 / 8
Argentina	270	17.000
Brazil	6.220	45.200
Colombia	1.200	35.000
Cuba	34,7	3.110
México	345	3.670
Peru	1.100	50.300
Venezuela	856	36.830
SOUTH AND LATIN AMÉRICA	**10.683**	26 / 6

Algeria	13,87	460
Angola	184	15.376
Camerún	268	18.711
Egypt	2,8	43
Guinea	226	29.454
Lybia	0,6	100
Sierra Leone	160	34.957
Southafrica	44,8	1.011
ÁFRICA	**3.988,1**	11 / 13
Saudi Arabia	2,4	119
China	2.800	2.231
United Arab Emirates	0,15	64
India	1.850	1.896
Indonesia	2.530	12.251
Japan	547	4.344
Kuwait	0,02	11
Malassia	456	21.259
Turkey	196	3.074
ASIA	**12.686,5**	36 / 60
Australia	343	18.596
New Zealand	313	89.400
OCEANIA	**1.539,3**	5 / 1

Water problems in the World (6)

- Water problems per country



In 2050, two predictions are found with respect to water scarcity:

- *2,000 millions in 48 countries.*
- *7,000 millions in 60 countries.*

Water problems in the World (7)

- As well as water supply is not ensured (1,100 million of people), water quality is not good: 2,400 million do not have a sanitation system (1 l. of waste water contaminates 8 l. of fresh water).
- Vicious cycle of powerty, illness, water and fail of sanitation.

Without water supply

Asia	65%	80%
Latin America, Caribbean	6%	5%
Europe	2%	2%
Africa	27%	13%

Without sanitation

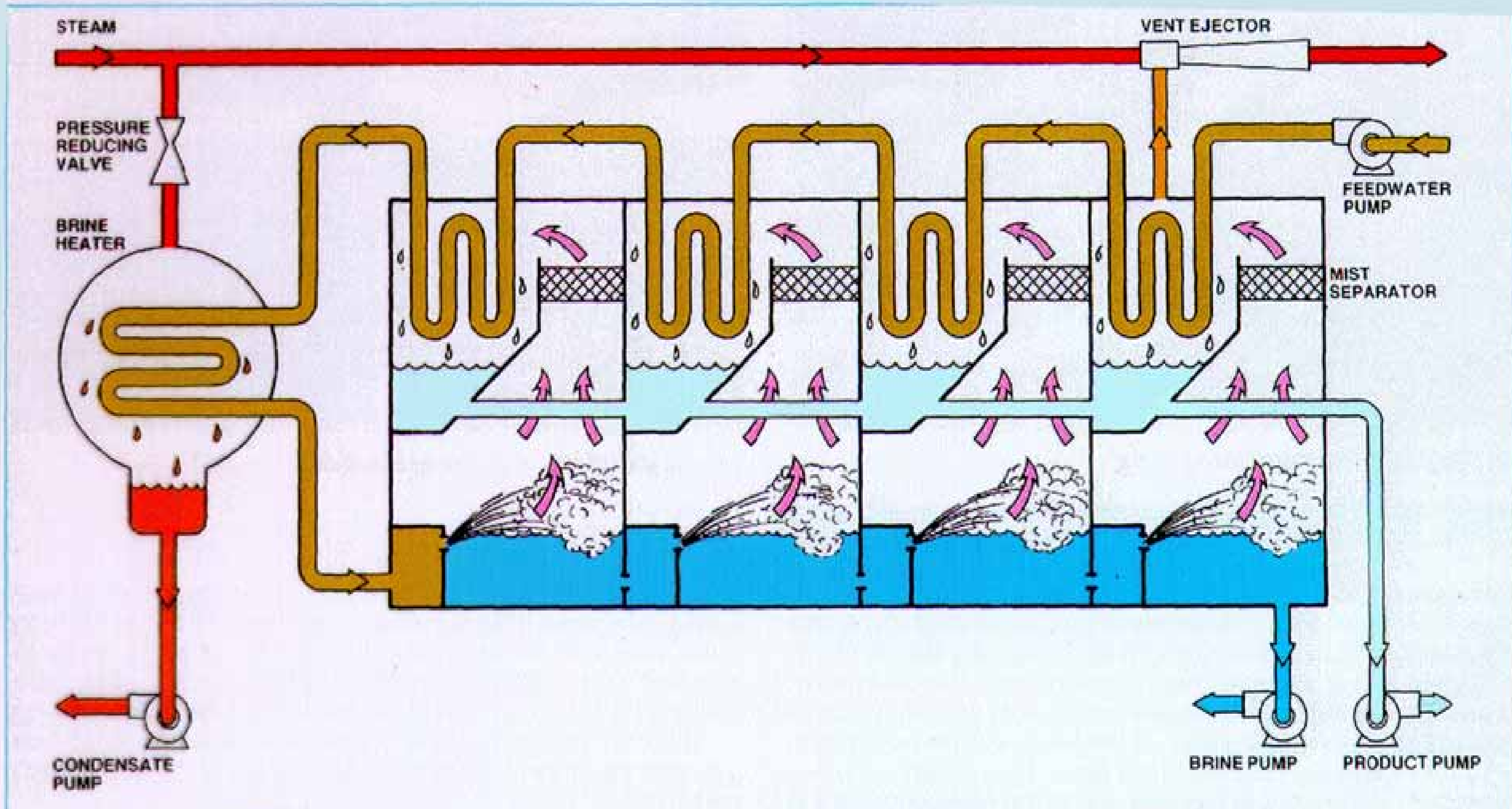
Desalination as a new source... (1)

- Desalination is a very promising alternative for increasing water resources from seawater (on-shore) or brackish waters (inland territories).
- Leon Awerbach (2002) said: “The XIX Century was the century of gold. The XX Century was driven by oil. In the XXI Century, water will be the most important resource. Desalination will deliver the promise not only to create new water but also to produce fresh water at dramatically reduced cost”.

Desalination as a new source... (2)

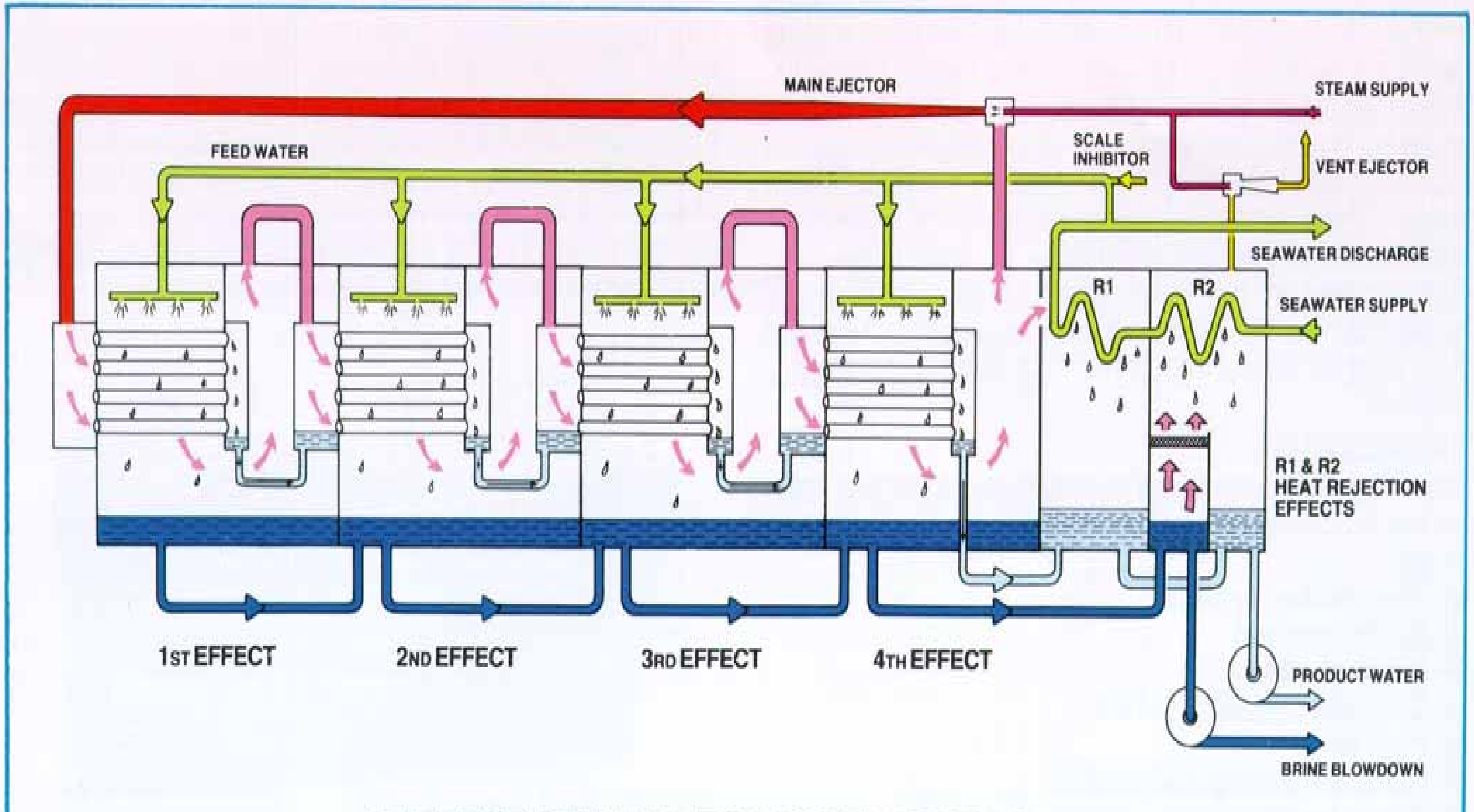
- However, desalination consumes a lot of energy: its costs could not be affordable for most of the population.
- Furthermore, desalination provokes environmental impacts that should be mitigated.
- Nowadays, only the 0.2-0.3% of the demanded water is desalted, and represents the 0.3-0.4% of the total primary energy consumption.

Technologies: MSF (distillation)



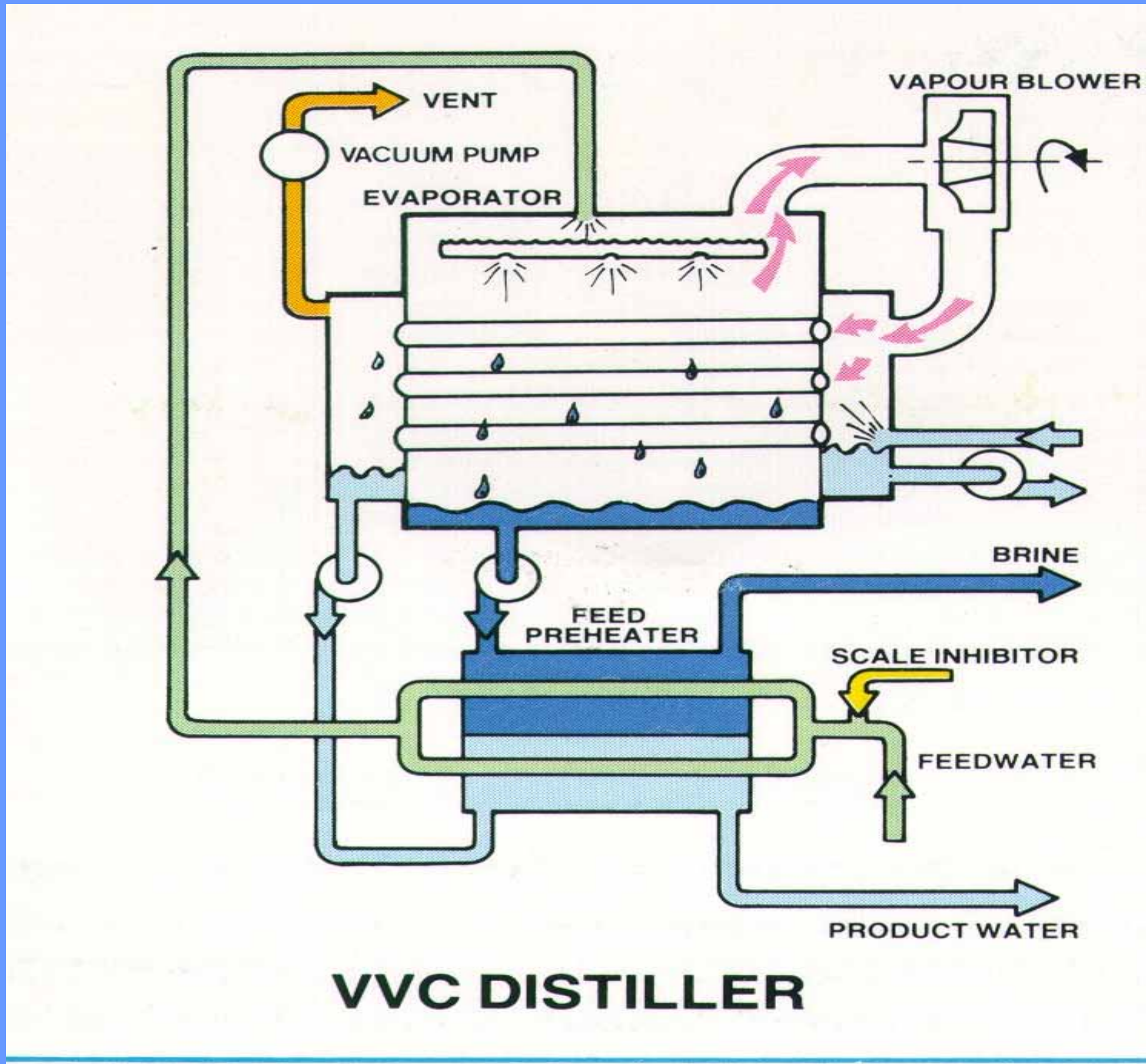
TYPICAL FLOW DIAGRAM OF ONCE-THROUGH MSF PLANT.

Technologies: MED (distillation)

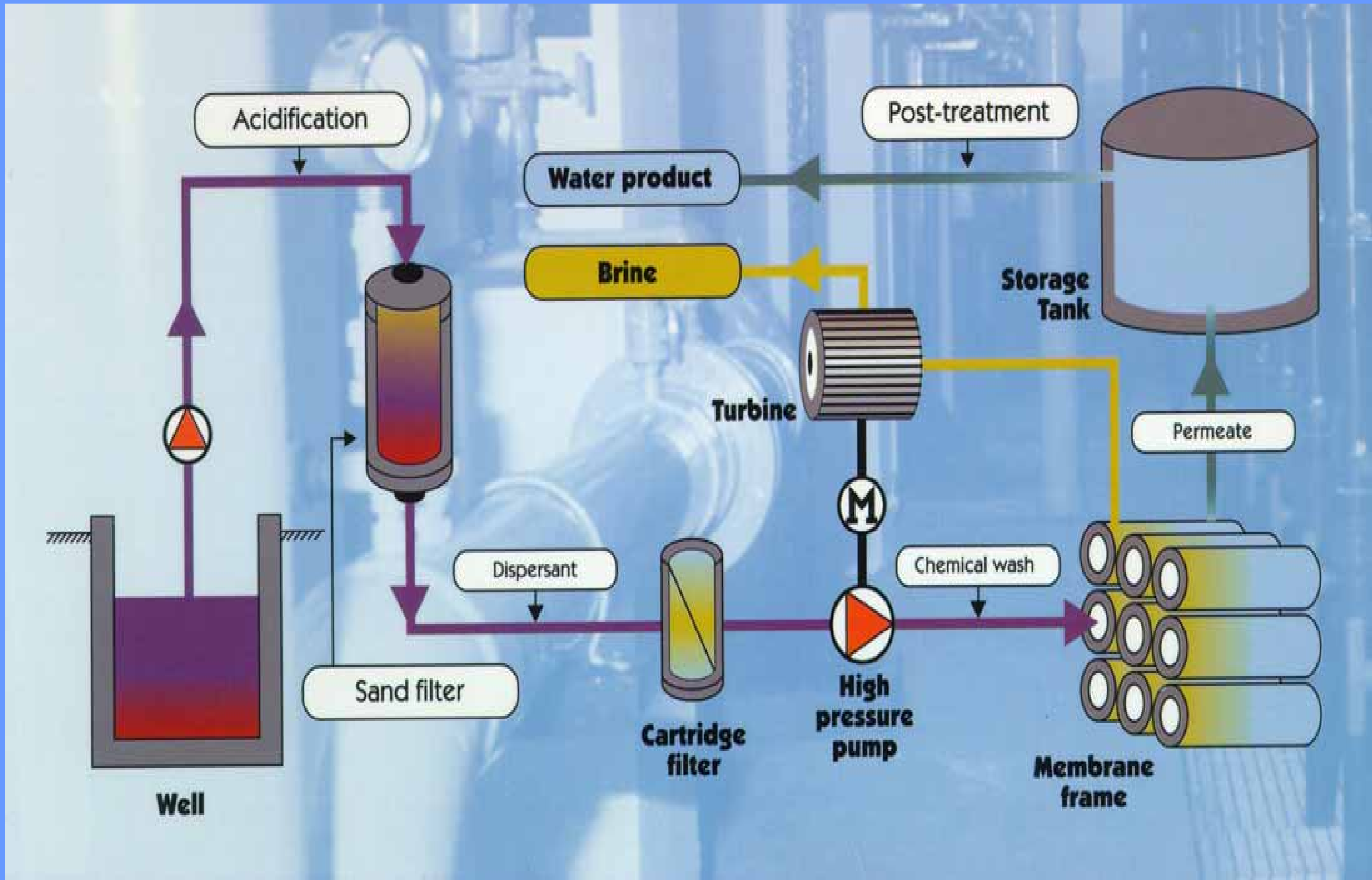


4-EFFECT REHEAT PROCESS FLOW DIAGRAM

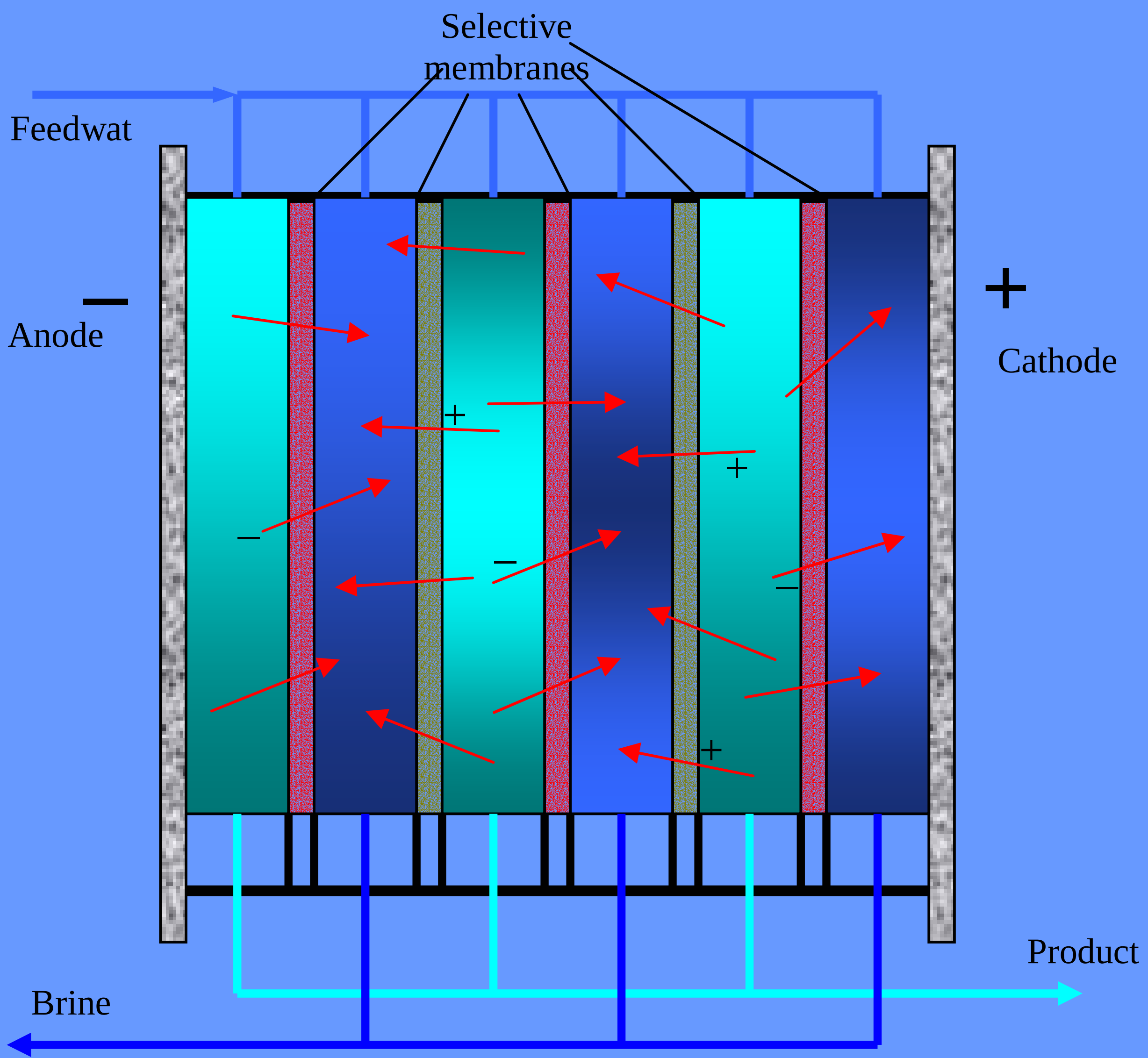
Technologies: VC (distillation)



Technologies: RO (membranes)



Technologies: ED (membranes)



Technologies: a comparison

	MSF	MED/TVC	VC	RO	ED
Energy required	thermal + mech.	thermal + mech.	mechanical	mechanical	electrical
Operation temperature (º C)	110	70	70	45	45
Power consumption (kWh/m^3)	3-5	1-2	8-12	3-6	0.8-1.5
Raw water quality (ppm)	> 50,000	> 50,000	>50,000	< 50,000	< 3,000
Product quality (ppm)	< 50	< 50	< 50	< 500	< 500
Unit capacity (m^3/d)	10,-50,000	5,-20,000	1,-5,000	10,-100,000	1,-10,000
Plant reliability	high	high-medium	low-medium	high-medium	high
Increment of capacity	difficult	difficult	difficult	easy	easy
Surface required	high	high-medium	low	low	Low

Desalination: evolution

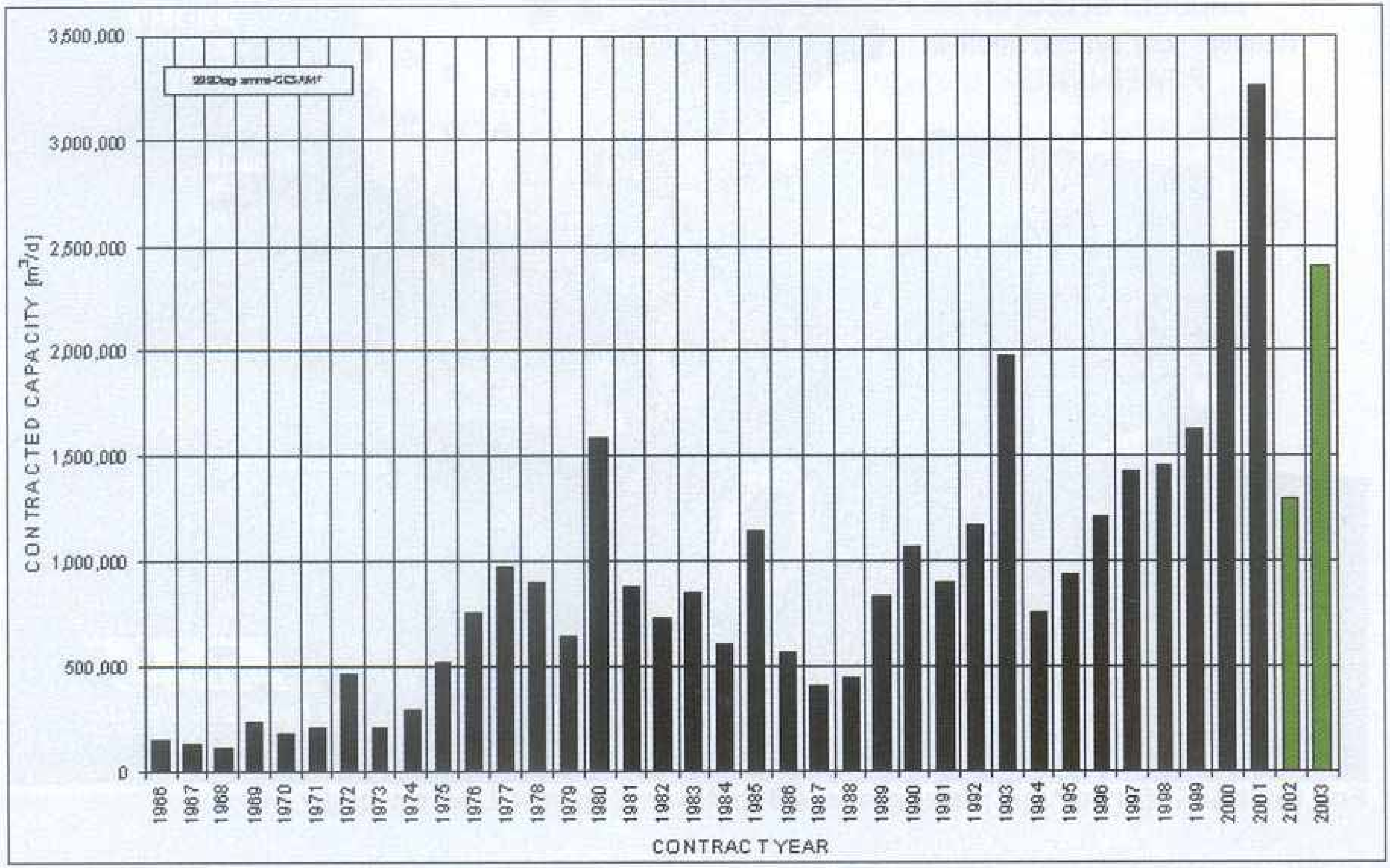


Fig. 1: Annual capacity of desalination plants contracted worldwide

Desalination: evolution

Fig. 2: Cumulative contracted capacity and capacity in operation

Desalination: evolution

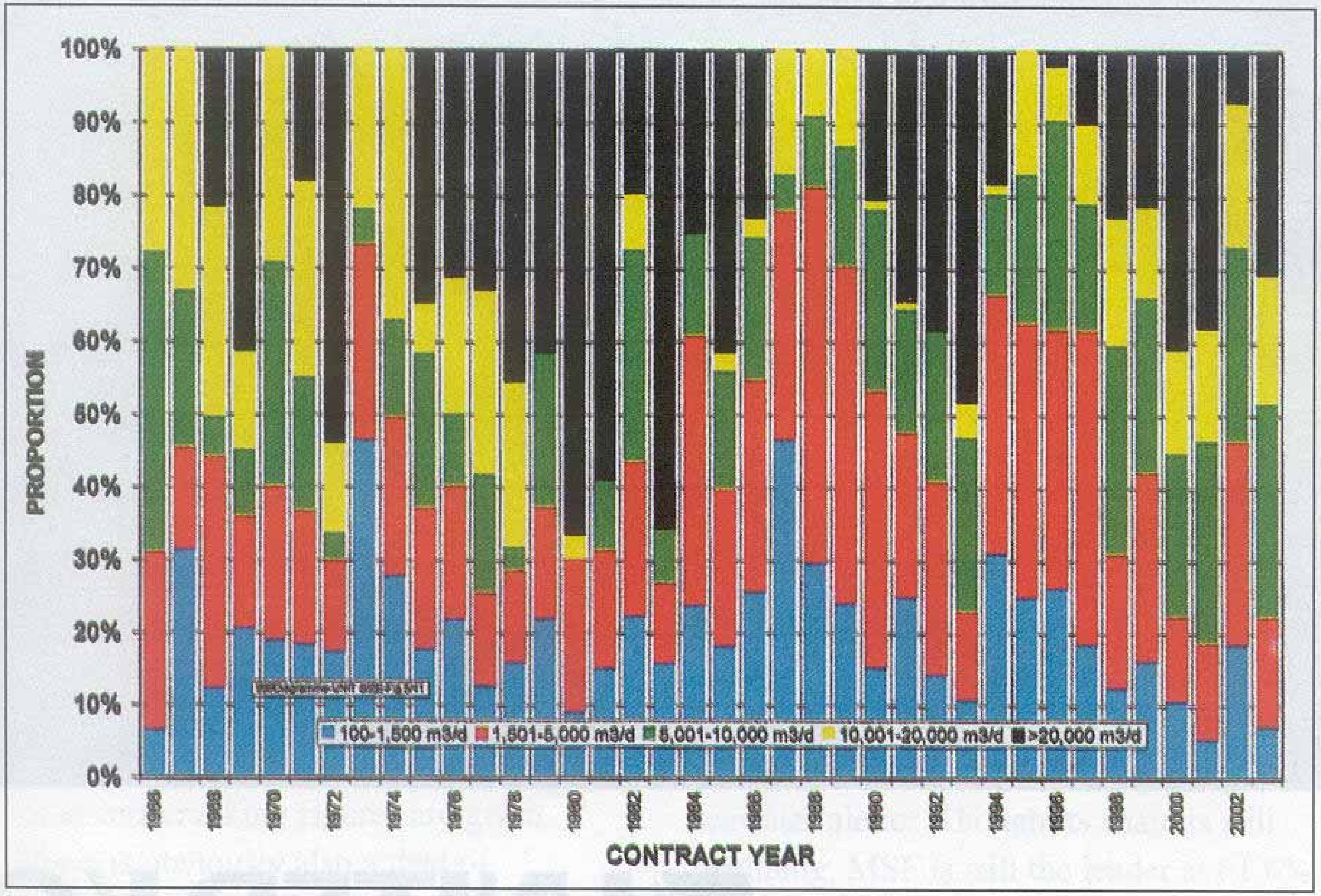


Fig 4: PROPORTION of UNIT SIZES for all land-based desalting plants capable of producing 100(m³/d)/UNIT or more of fresh water vs. CONTRACT YEAR

Desalination: evolution

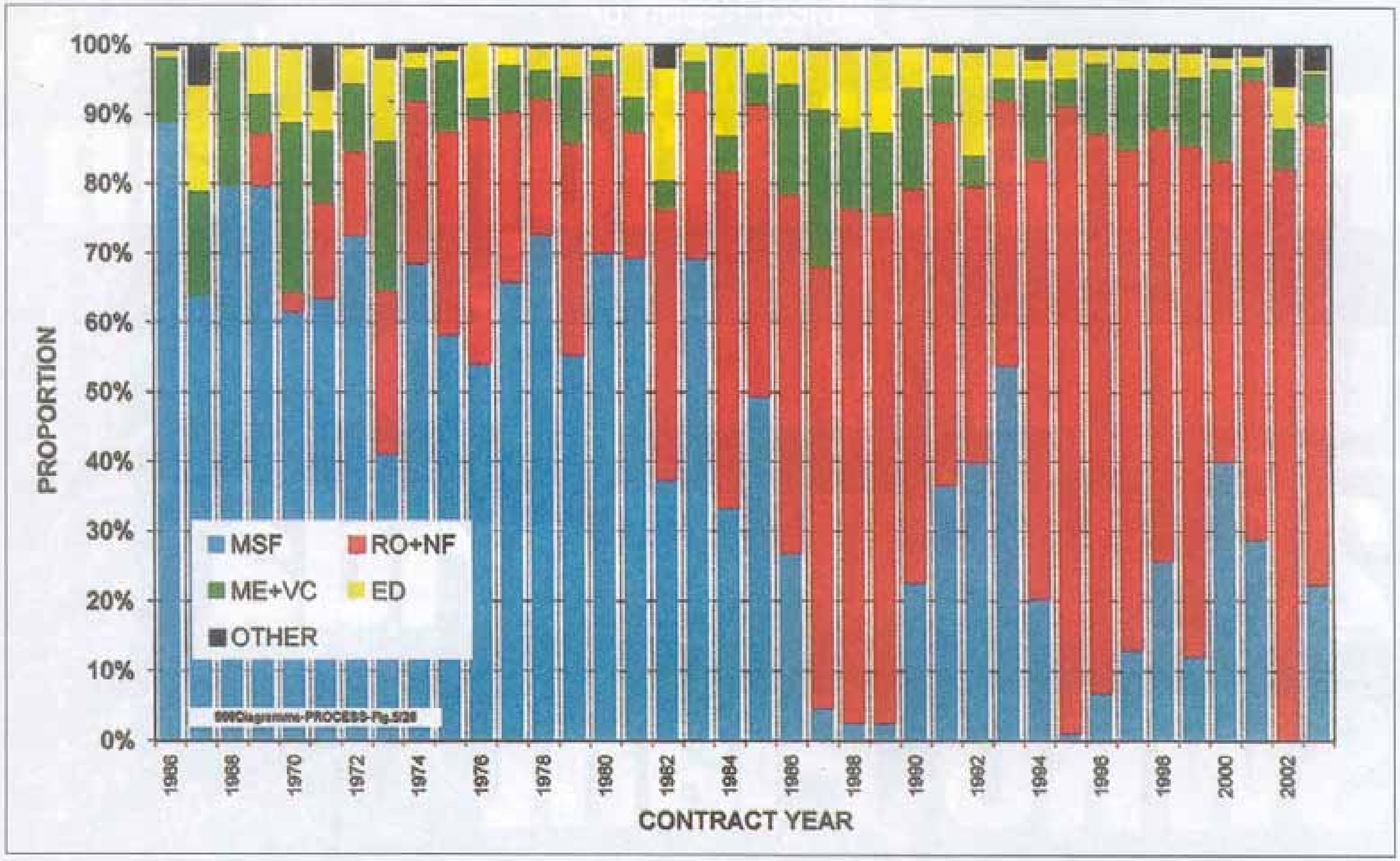


Fig 5: PROPORTION of PROCESSES all land-based desalting plants capable of producing 100(m³/d)/UNIT or more of fresh water vs. CONTRACT YEAR

Desalination: evolution

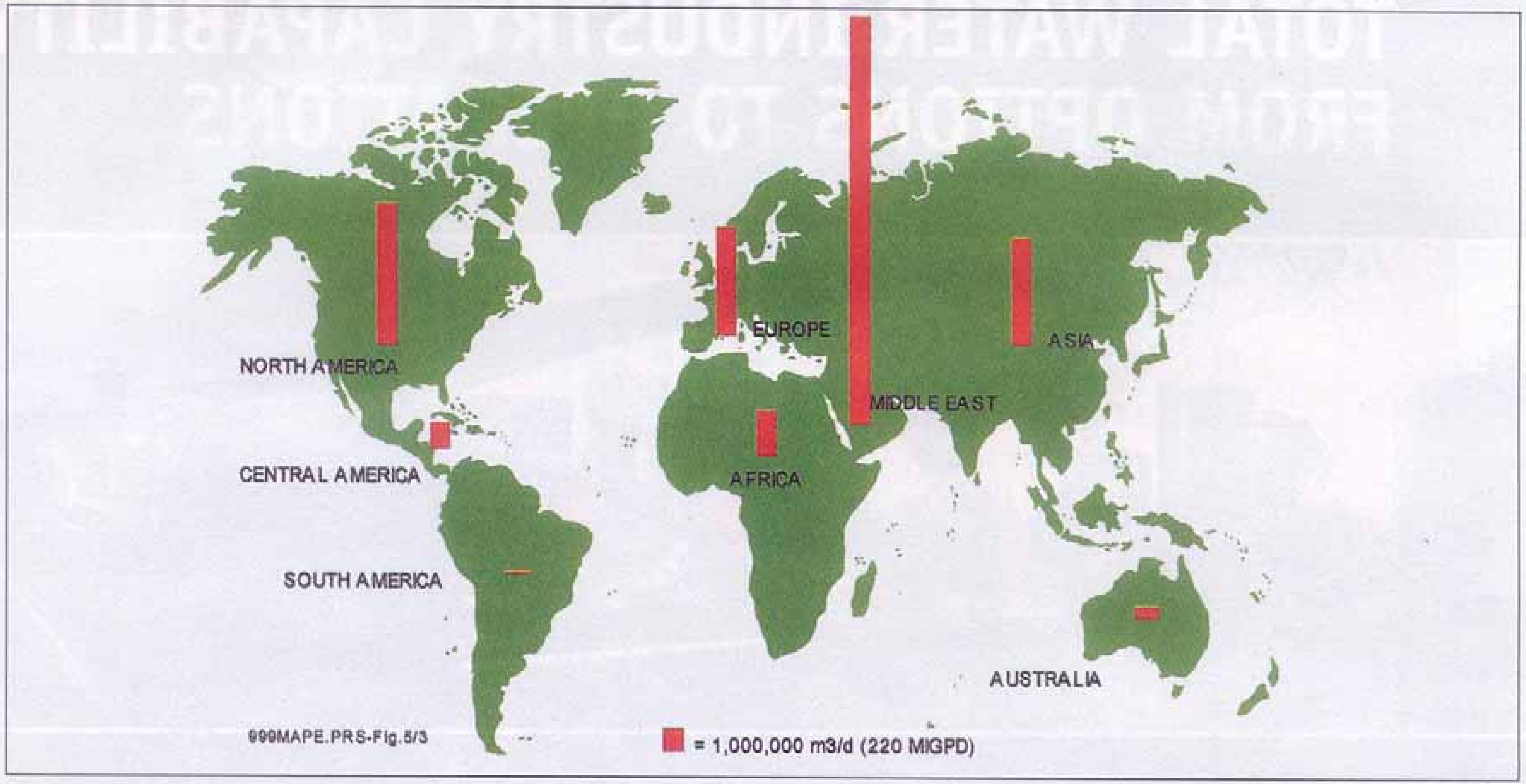


Fig 3: CAPACITY of all land-based desalting plants capable of producing 100(m³/d)/UNIT or more of fresh water vs. REGION

Desalination in the Middle East

- Saudi Arabia, UAE and Kuwait are respectively the 1st, 3rd and 4th country in installed capacity.
- Desalination has permitted the economic growth of that countries: more than 50% of their resources are desalted seawaters.
- MSF is almost the unique technology: MED and VC are less important. RO is increasing its participation, especially in hybrid plants.
- Private companies can manage new plants.

Desalination in US, LA and Caribbean

- US is the 2nd country in installed capacity and the leading in RO technology (brackish waters and softening techniques).
- The growing tourism in the Caribbean islands has been supported by desalination, firstly with MED and later with RO.
- In Latin America, desalination is a local solution for industry and tourist resorts.

Desalination in E and SE Asia

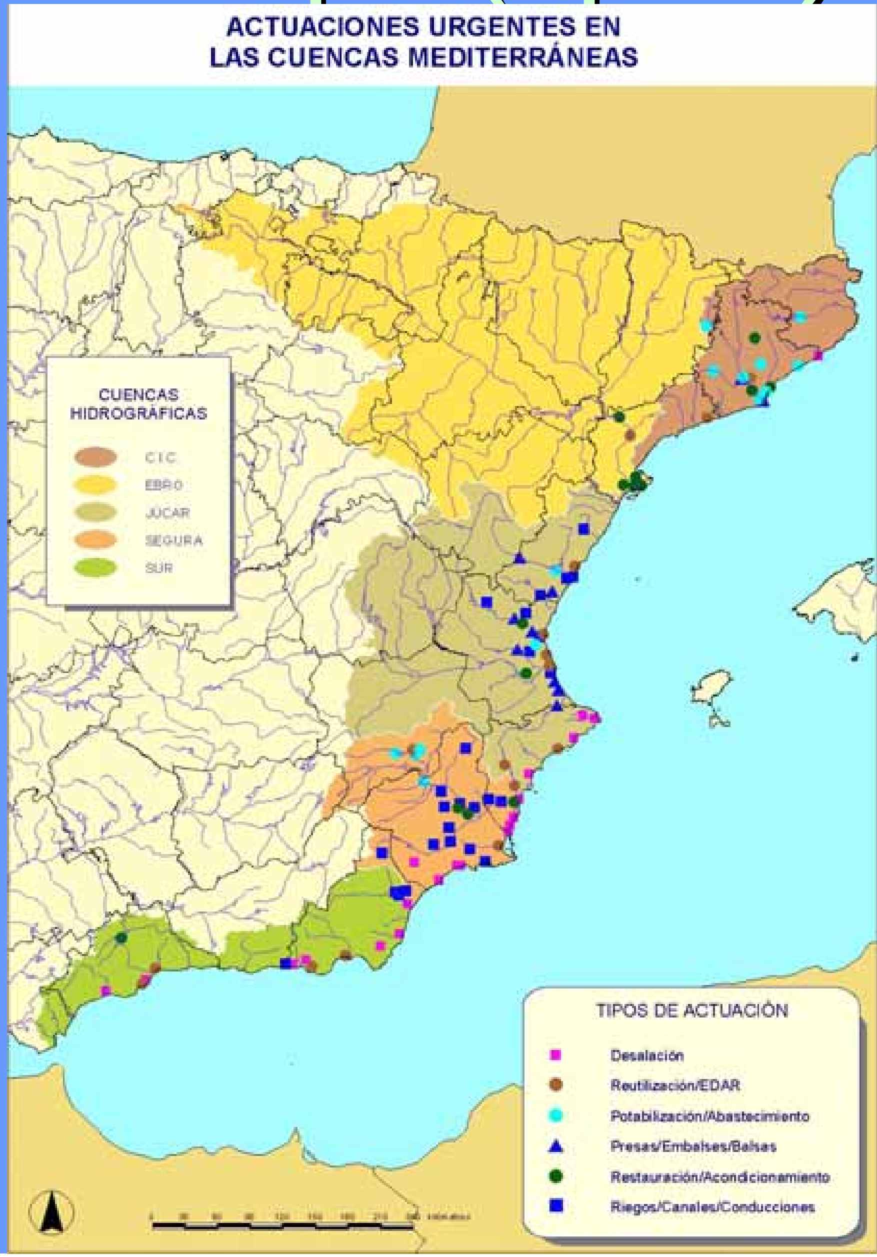
- In Japan, Korea, Taiwan and Indonesia desalination is mainly used for industrial purposes (ultrapure waters) or isolated locations.
- For highly populated countries (China and India) desalination is not foreseen in the next future (economy): hydraulic projects are preferred.

Desalination in Europe and NA

- Spain is the 5th country in capacity (1,6 hm^3/d) and the 2nd in RO. The future is very optimistic: 336 hm^3/y for the Spanish Levante in the NHP 2001, and 621 hm^3/y more in the NHP 2004. Is the leader in using desalted water for agriculture.
- Italy is the next, but Cyprus, Malta and Israel (400 hm^3) are dependent on desalted water.
- The rest of Europe only uses desalination for industrial purposes.
- The NA region is similar to Middle East but capacity is not so representative.

Desalination in Europe (Spain)

- The NHP 2004: A. G. U. A. Plan includes 20 new SWDP, water reuse, improve irrigation systems



Costs of desalination (1)

- Desalination costs depend on the location and applied technology.
- Two main costs: investment and running costs.

Technology	Capacity range (m^3/d)	Specific investment cost (€/m^3d)
MSF	10,000-50,000	1,680-1,080
MED/TVC	5,000-20,000	1.080-800
VC	1,000-5,000	1,500-1,020
RO	10,000-100,000	900-550

Costs of desalination (2)

- Despite the low cost of energy (fuel), distillation technologies are more expensive than RO (the lowest project is about 0,7 $/m^3$).
- The total cost for some recent RO BOOT projects

SWDP	Tampa bay	Trinidad	Larnaca	Dhekelia	Singapore	Askhelon	Algiers
Capacity (m^3/d)	95,000	135,000	40,000	40,000	136,000	274,000	200,000
Feedwater salinity (ppm)	26,000	38,000	40,000	40,000		40,000	40,000
Contract Year			2000	1996	2002	2002	2003
Years of contract	30	23	10	10	20	25	25
1st year price* ($/m^3$)	0.46	0.71	0.73	1.09	0.45	0.52	0.818

Environmental impacts (1)

- Thermal pollution provoked by distillation plants is quite important in the Arabian Gulf.
- Brine discharge of RO plants needs special treatment to avoid damaging endemic flora species (Posidonia Oceanica).
- Energy consumption provokes CO_2, NO_x and SO_x emissions. Integration with renewable sources is not widely extended yet.
- Desalted brackish waters are very dangerous if brine discharges are not properly managed.

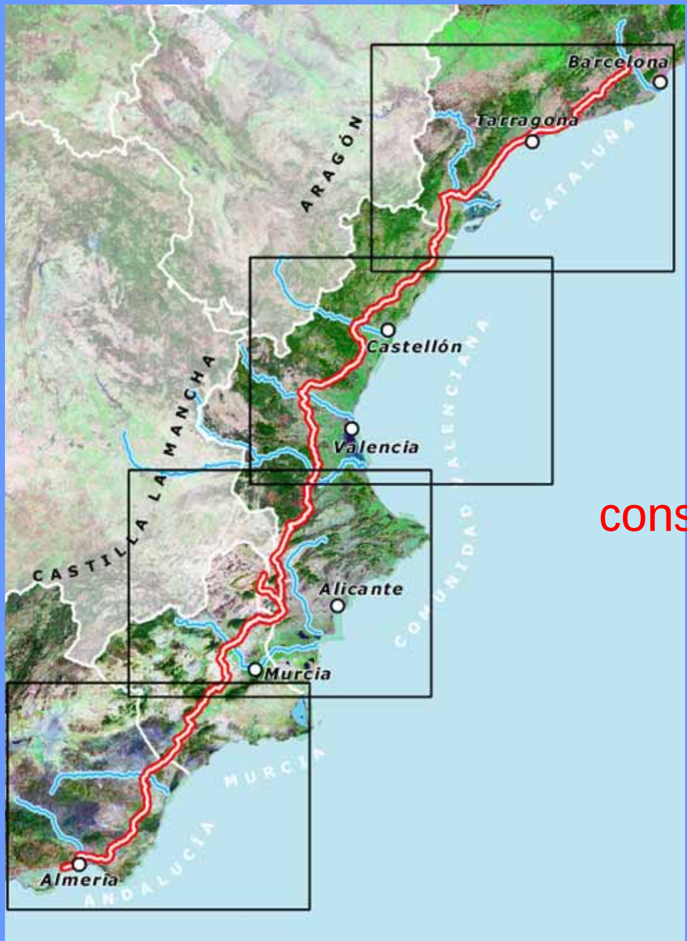
Environmental impacts (2)

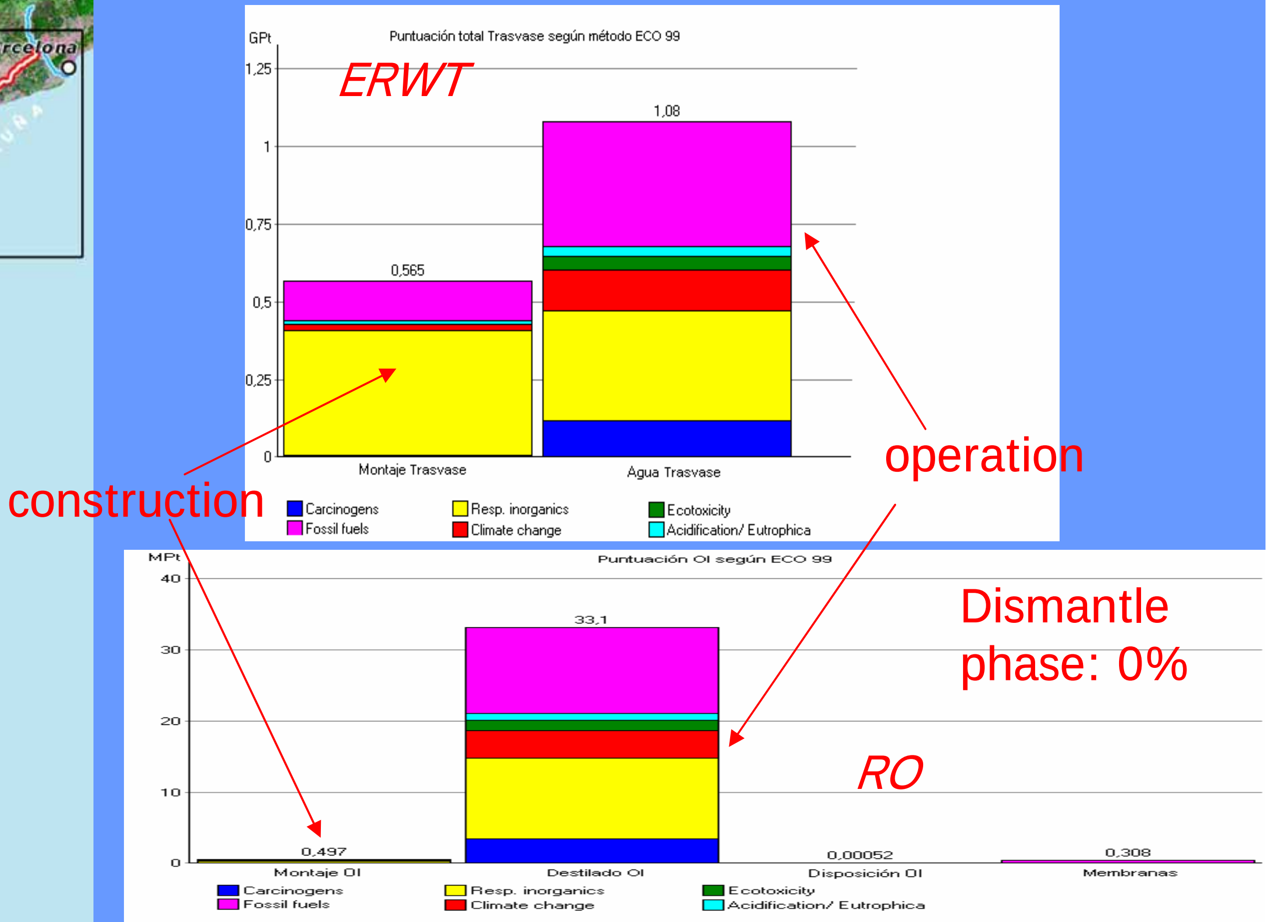
- A desalination facility should be compared with other water supplying alternative.
- It is important to compare the entire Life Cycle of the process: LCA techniques calculate the impact of the assembly, operation but also the final disposal of the installation.
- An example: comparing with the ERWT of the NHP 2001.

	Unit	RO (4 kWh/m^3)	RO (3 kWh/m^3)	RO (2 kWh/m^3)	Transfer (50 years)	Transfer (25 years)
Eco-indicator 99	GPts	2.62	2.04	1.46	1.86	2.20
Ecopoints 97	GPts	43,400	34,200	25,100	29,900	35,900
CML 2 baseline	-	0.546	0.414	0.283	0.362	0.378

Environmental impacts (3)

- ... comparing the ERWT with RO: phases





Future innovations (1)

Technology (costs)

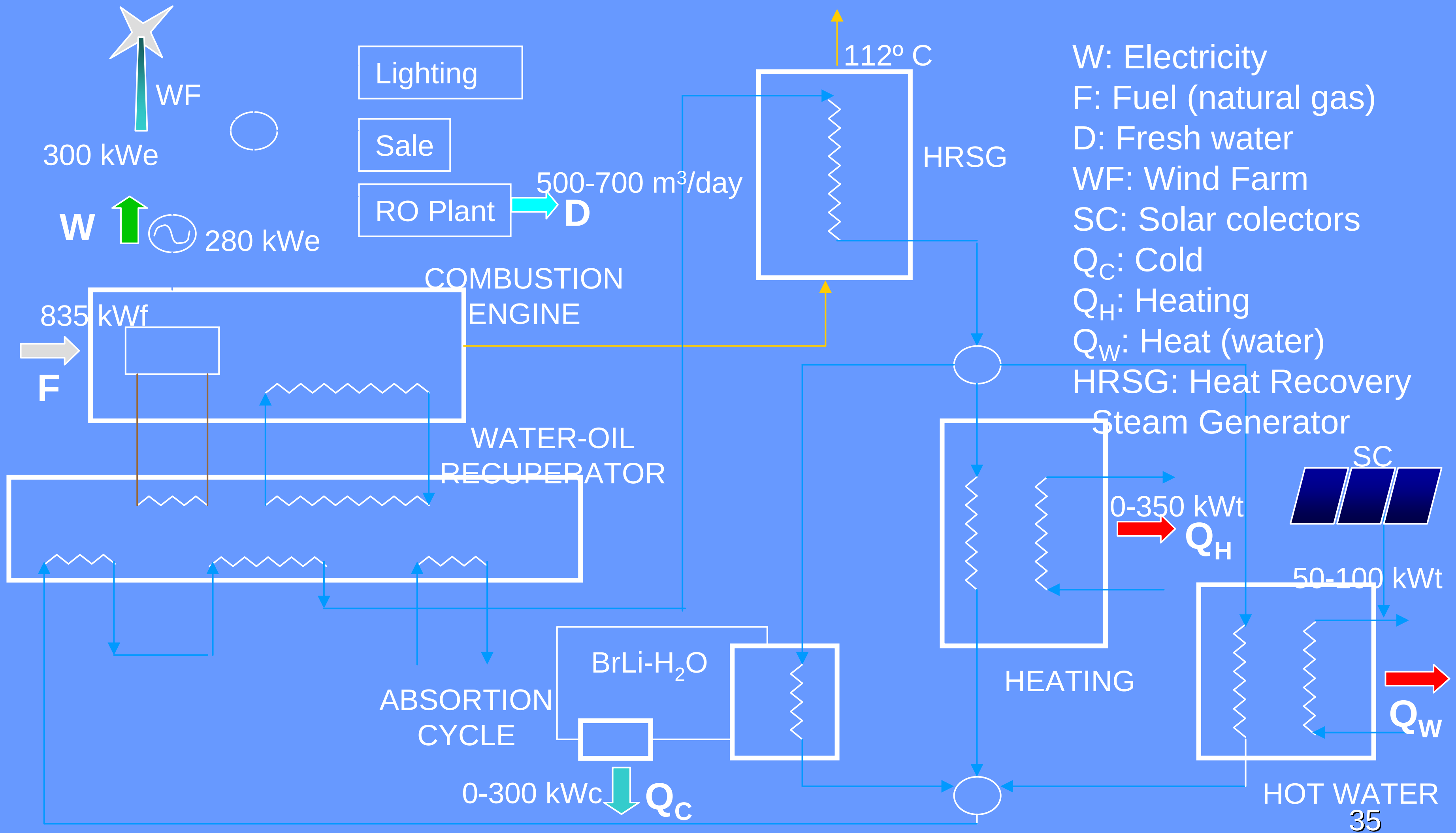
- Integrate with power (dual) plants.
- Poligeneration: energy, cold, heat + water
- Include hybrid plants (MSF/MED + RO).
- Improve materials and the utilization factor.
- Use softening techniques (UF/NF) to increase TBT in MSF units.
- Reduce the RO pretreatment.
- Include ERS for big RO plants.

Future innovations (1)

- Integrating with power (dual) plants.

Future innovations (1)

- Poligeneration: energy, cold, heat + water



Future innovations (2)

Environmental impacts

- Reduce energy consumption.
- Reduce corrosion of materials.
- Use sound-insulated materials.
- Reduce the use of chemicals and chlorine if possible.
- Reduce thermal contamination with cooling exchangers.
- Increase length of brine outfall pipes.

Conclusions (1)

A water supply alternative

- WDM techniques should always be applied before using desalination: efficient irrigation methods, water markets, water reuse, saving devices for households...
- Desalination should be the water supply solution less aggressive to budgets and to the environment.

Conclusions (2)

Desalination costs

- Currently, 3% of global drinking water is desalted, but concentrated in the Gulf (rich countries).
- Costs have fallen to affordable levels for some communities, but no major breakthroughs are expected in the near future.
- It should not be used for irrigation if subsidies are given.

Conclusions (3)

Environmental charges

- Desalination has local impacts that can be avoided by increasing water costs.
- The global impact is its energy consumption: thermodynamic limit for desalting seawater is > 1 kWh/m^3.
- Desalination will not have any penalty if the problem of a clean energy production is solved.