DME

DEUTSCHE MEERWASSERENTSALZUNG GMBH

Company Presentation

Deutsche MeerwasserEntsalzung (DME) GmbH

2017

Duisburg, Germany

DME* – The Company

Water must be available to every human being in a sufficient quality and volume and it must be supplied under socially acceptable and environmentally friendly conditions. *(The vision of DME e.V.)*

The biggest part of the world's surface (71 %) is covered with water. Only 3 % of the water resources worldwide is portable water and the rest of 97 % is salty water, not drinkable for human beings.

DME e.V. was founded in May 2003 and was committed to uniting the know-how existing in Germany with the interests of the economy, the sciences and politics and in creating a platform for exchanging experience and for offering further education on seawater desalination.

*DME abbr. of Deutsche MeerwasserEntsalzung (DME) GmbH

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DME – The Association and Company

- **DME e.V.**

  a non-profit & non governmental Association with:

  1. DME Board
  2. DME Advisory Board
  3. DME TWA

- **DME GmbH** Company

  1. DME Managing Director
  2. DME Stuff
  3. DME Network Consultants and Brands

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DME GmbH: Services (1-2)

- Desalination Consulting Services
  - Lender's engineer for financing banks and investors
  - Assessor for German Ministries (Federal and States) and Universities
  - Owner's engineer for the project company and investment appraisals
  - Technology assessment and supported developments
  - Due diligence surveys
  - Standard, customized expert reports
  - Desalination plant raw data collection
- Structured technical data (Desalfacts)
  - Patents, R&D articles, technology profiles, company profiles, country profiles, desalination news
- Piloting, pre-testing, field trial
- Independent membrane performance monitoring
- Desalination Education and Training
  - International seminars and workshops in desalination

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DME GmbH: Services (2-2)

- Confidential survey of information
- Strategic consultancy in M&A and company's development
- Evaluation of technologies and companies in the desalination industry
- Integration of DME seminars in training programs company's
- Intermediation of trainees
- Techno-commercial planning assistance
- Analysis resp. control of documents such as specifications, offers, technical drawings etc.

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Selection of References

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Basics – Ocean Salinity

- **How salty is sea water?**
  - Regular Ocean Water
    - 35.000 ppm Total Dissolved Solids (TDS)
    - 3.5 mass-% of salt
  - Persian Gulf
    - 50.000 ppm TDS
  - Baltic Sea
    - 7.000 ppm TDS

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Basics – Ocean Salinity

- **Which salinity should potable water have?**

  – Max. 500 ppm when drinking permanently, periodically 1.000 ppm

  – pH value and composition of salts to be observed as well

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Demand and Supply of Fresh Water Diverges – Driver for Desalination

- **Consumption increases**
  - Population grows
  - Agriculture (with irrigation) needs large quantities

- **Natural Water Supply decreases**
  - ground water level goes down (at many sites)
  - ground water becomes salty (near the coasts)
  - surface water becomes dirty (with increasing distance to the spring)

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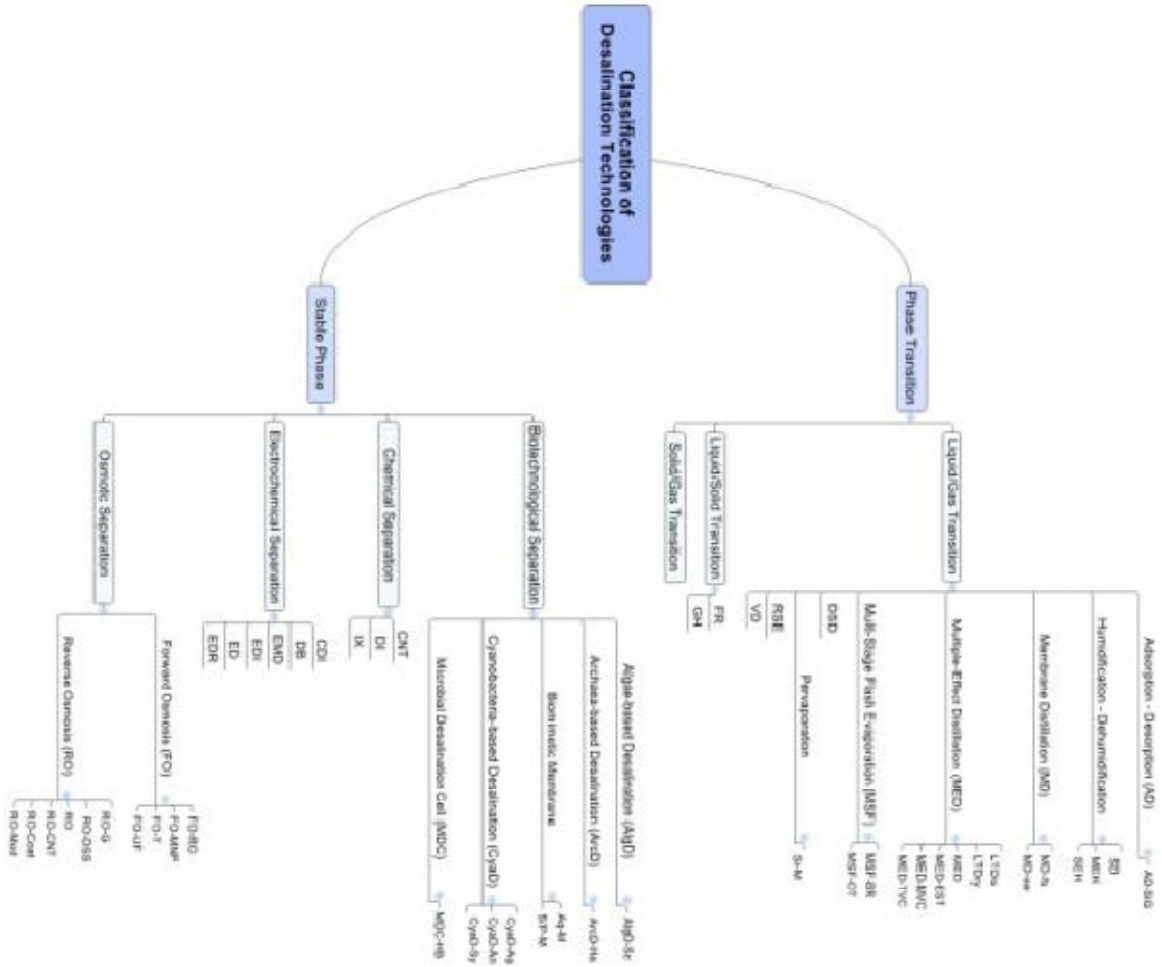
General Overview of Desalination Methods



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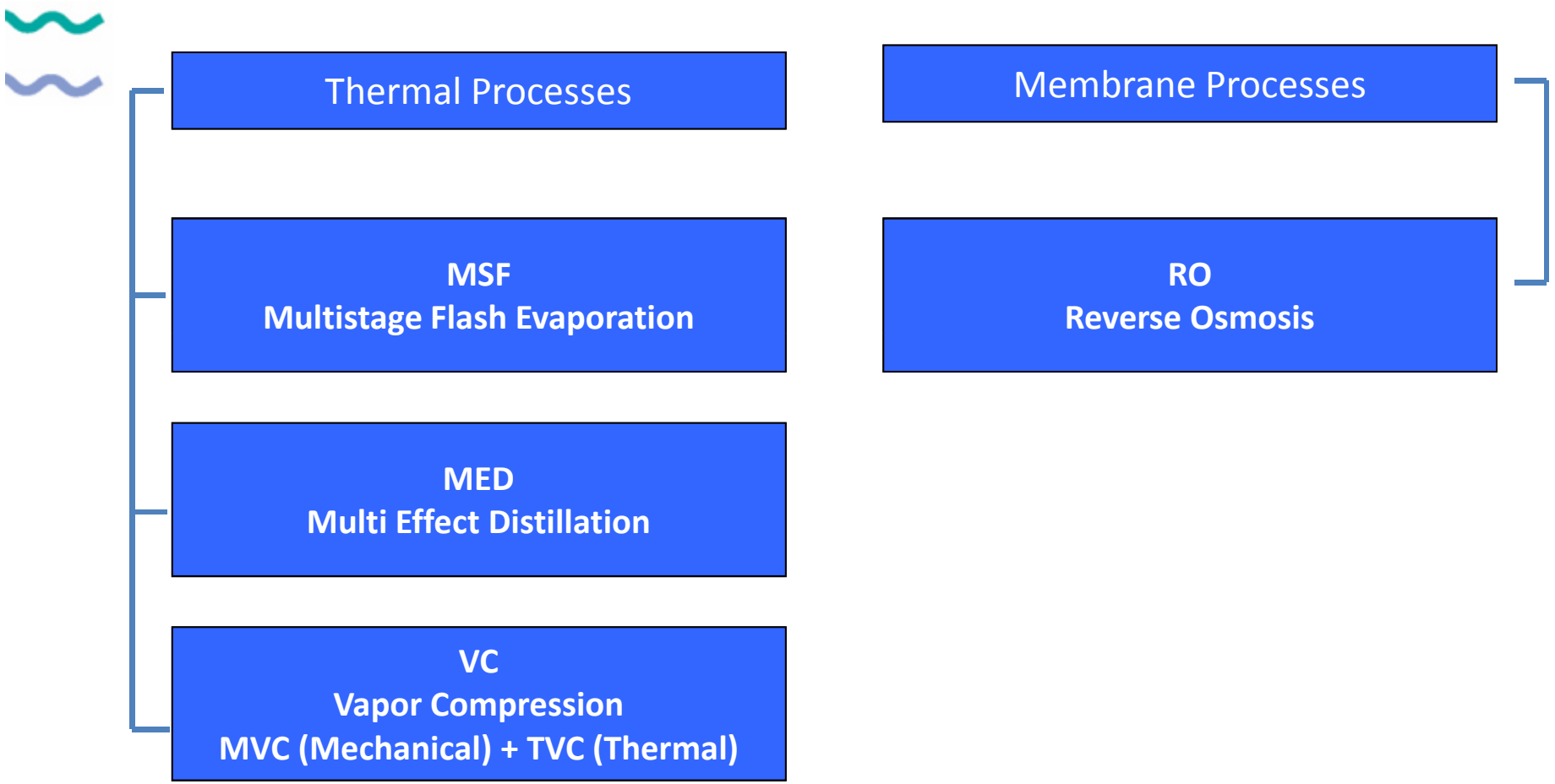
Most used Processes in Desalination



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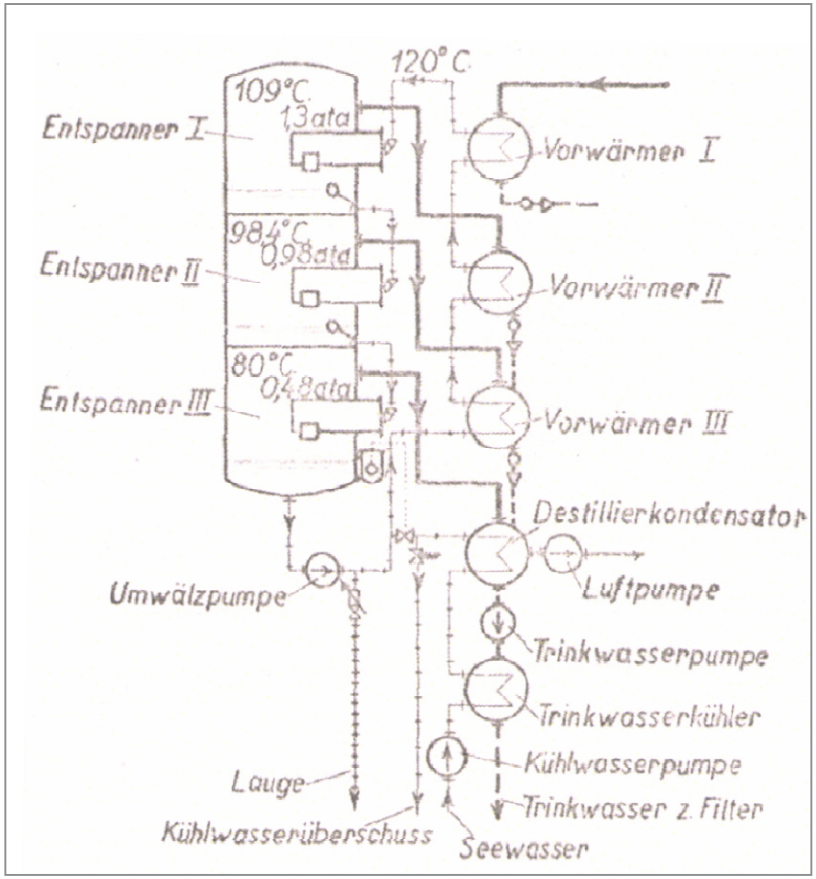
Historical Background – Multi Stage Flash Evaporation (MSF)

- **Process scheme of a multi stage flash (MSF) evaporator , published 23. – 26. May 1934 in Germany during a seminar of “Schiffstechnische Gesellschaft” by Mr. R. Blaum**
- **“Process scheme of a 3-stage flash evaporator plant with brine recirculation”**



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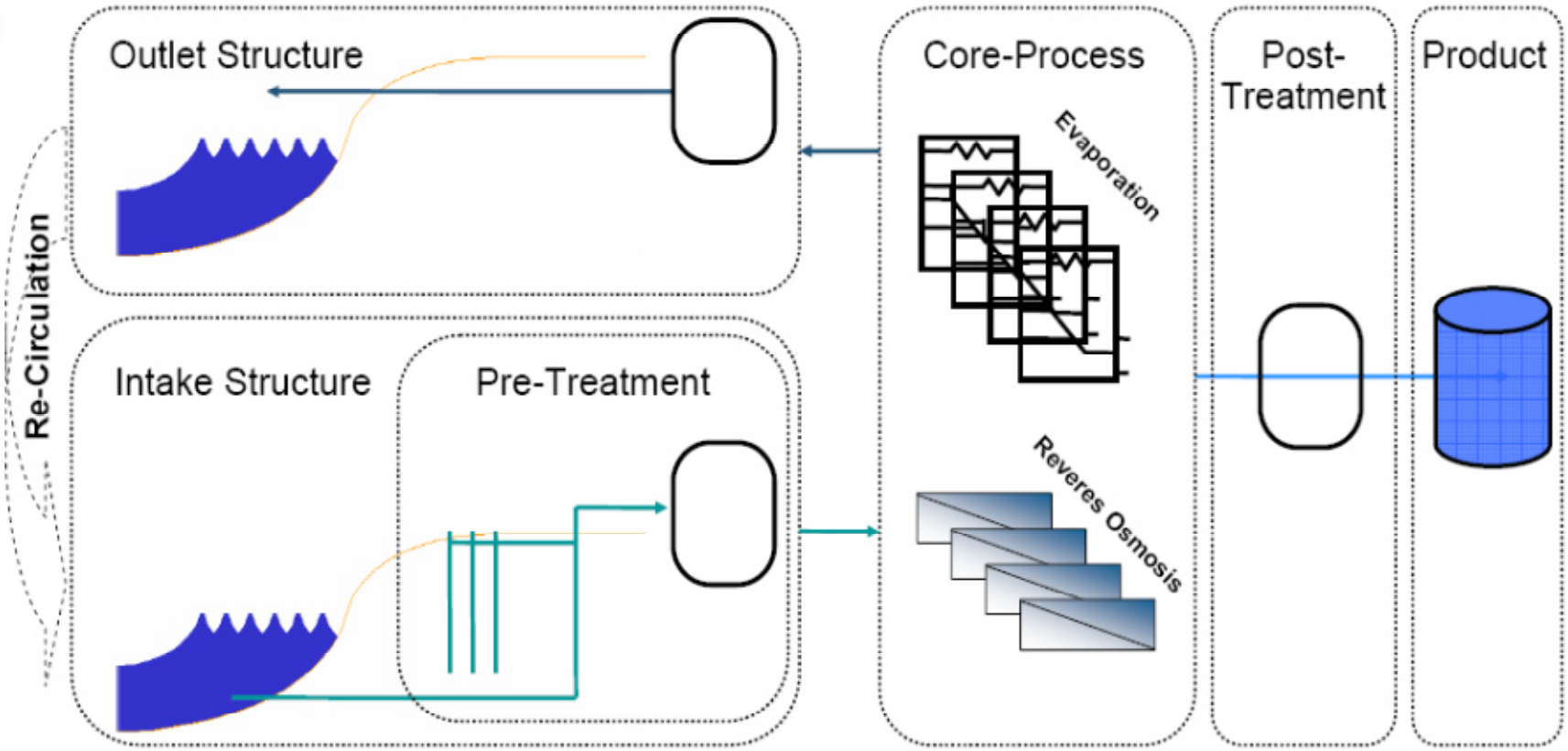
Desalination Process Overview



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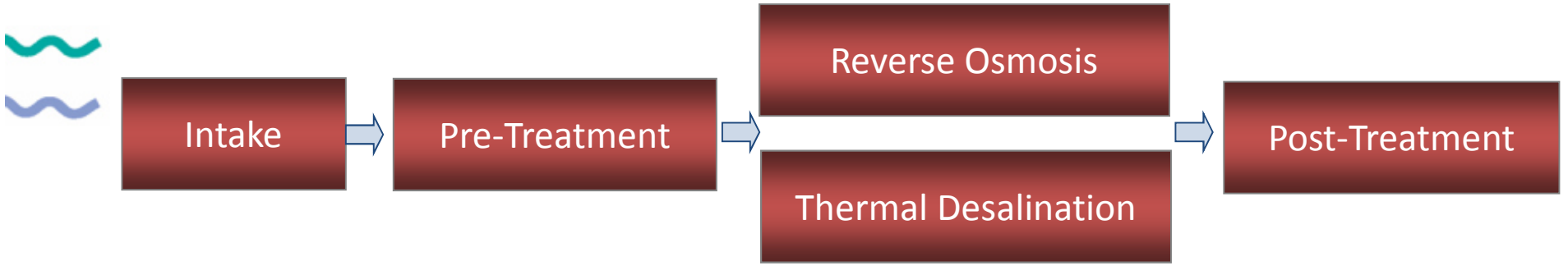
Desalination Treatment Process Blocks



- Groundwater
- Surface Water
- Sea Water (Open Intake)
- Sea Water (Beach Wells)
- Sewage Effluent

- Coagulation
- Sedimentation
- Flotataion
- Media Filtration
- Precoat Filtration
- Cartridge filtration
- Micro Filtration
- Ultra Filtration
- Anti Scaling Dosing
- pH adjustment
- Chlorine
- Ozone
- UV

- High Pressure
- Low Pressure
- Single Stage
- Multiple Stage
- Energy Recovery

- pH Adjustment
- Re-hardening
- Disinfection

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Desalination in Brief

- Main technology paths in desalination

1. MSF Technology
2. MED & MED-TVC Technology
3. Reverse Osmosis (RO) Technology

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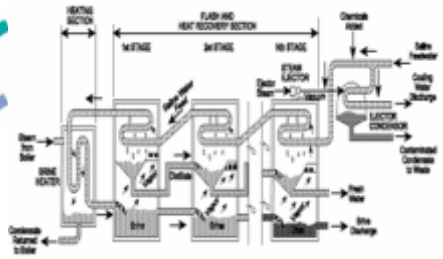
Main technology paths in desalination

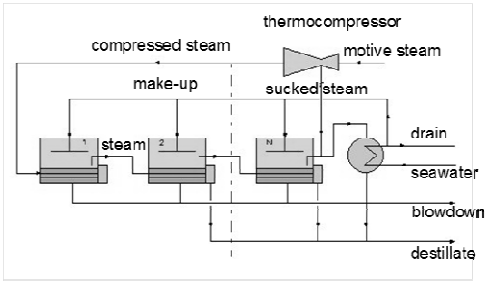


MSF Technology - pros

- Robust, fully developed process
- Very low consumption of chemicals
- Easily to couple with power stations
- Large unit sizes up to 70,000 m³/d

MSF Technology - cons

- High energy consumption
- Relatively high specific investment costs
- Coupling to power station mandatory
- Large volume of raw water necessary

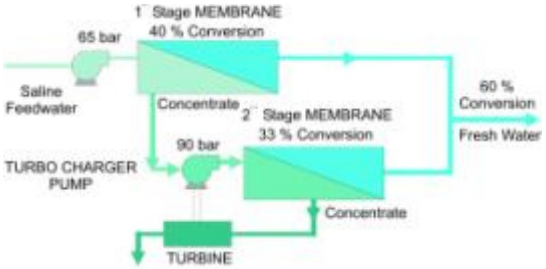


MED & MED-TVC Technology - pros

- Robust, developed process
- Ideal for coupling with power stations
- Very low consumption of electrical energy
- Very low consumption of chemicals
- Unit sizes up to 37,000 m³/d

MED & MED-TVC Technology - cons

- High energy consumption
- Very high specific investment costs
- Coupling to power station proposed
- Large volume of raw water necessary (winter)



Reverse Osmosis (RO) Technology - pros

- Very low energy consumption
- Low specific investment costs and low ground area needed in case of an “ideal” raw water
- Small volume of raw water needed
- Unit sizes up to 12,000 m³/d

RO Technology - cons

- Operational costs for chemicals and membrane replacement very high
- High specific investment costs in case of difficult raw water
- Malfunctions can lead to serious plant damages
- Qualification of the operation and maintenance personnel must be higher than for thermal processes

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1. MSF Technology

MSF Technology - pros

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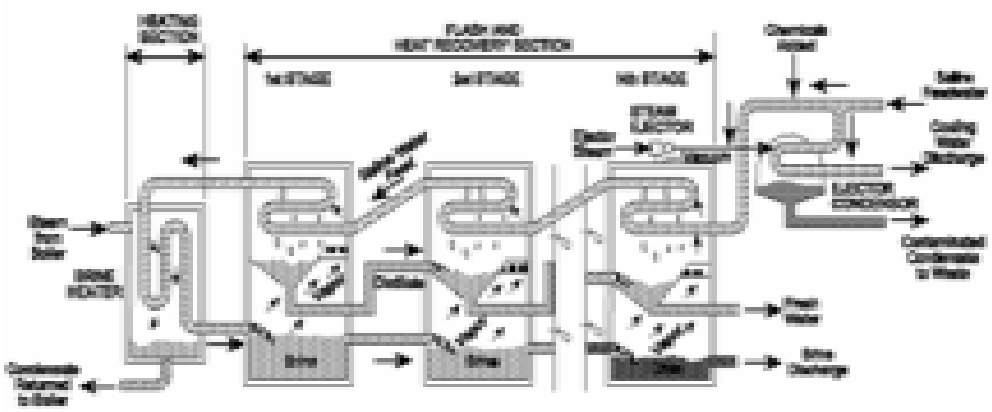

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2. MED, MED-TVC Technology

MED & MED-TVC Technology - pros

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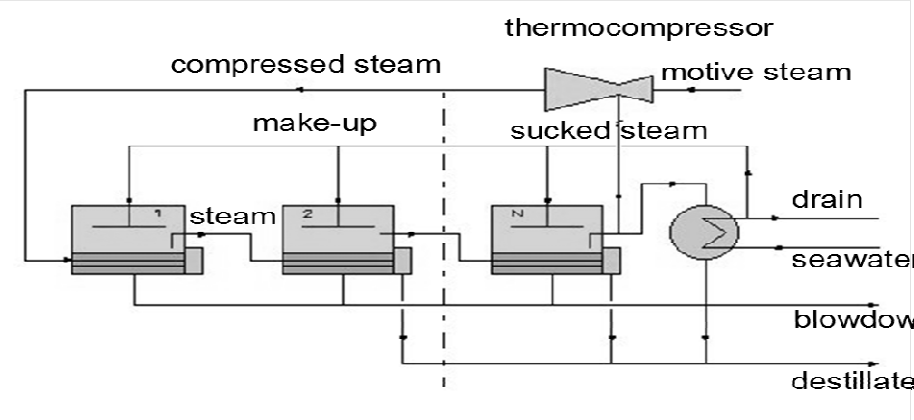

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3. Reverse Osmosis (RO) Technology

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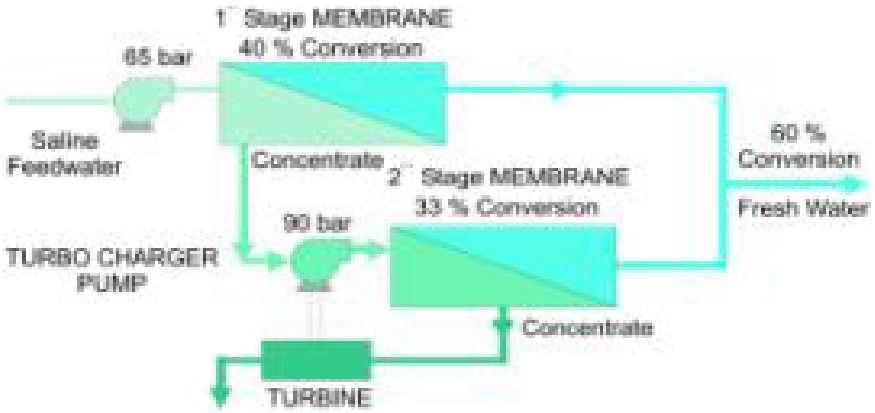

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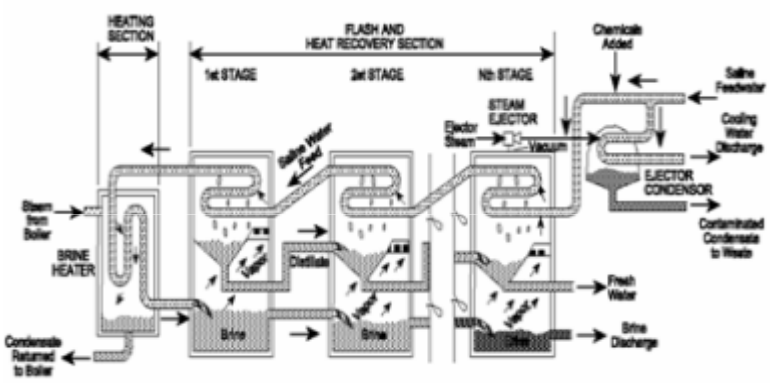
Line Desalination Technology: MFS is the largest single Unit Technology

Technology overview



Maturity

- Highest energy consumption of all desalination systems

Technical Description

- In the MSF process, seawater is heated in a vessel called the brine heater. This is generally done by condensing steam on a bank of tubes that pass through the vessel, which in turn heats the seawater. This heated seawater then flows into another vessel, called an evaporator stage, where the ambient pressure is such that the water will immediately boil. The sudden introduction of the heated water into the chamber causes it to boil rapidly, almost exploding or "flashing" into steam. Generally, only a small percentage of this water is converted to steam (water vapour), depending on the pressure maintained in this stage, since boiling will continue only until the water cools (furnishing the heat of vaporisation) to the boiling point.

Regional Diffusion

- Multi-stage flash plants have been built commercially since the 1950s. They are generally built in units of about 5,000 to 70,000 m^3/d. The MSF plants usually operate at the top feed temperatures of 90 to 120°C.
- Most of all existing Multi-stage flash (MSF) Plants are operated at the shore of the Persian Golf and the Middle East (particularly in Saudi Arabia, the United Arab Emirates, and Kuwait)

Typical Investors profile

- IWPP Projects with a large capacity in the Middle East
- Utilities in the Middle East (KSA, UAE, Kuwait, Oman)

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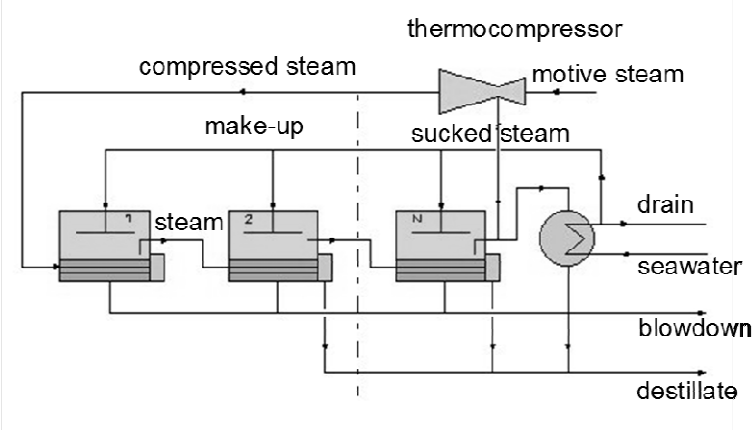
Line Desalination Technology: MED-TVC seems the most promising Desalination Technology

Technology overview



Technical Description

- The seawater is distributed onto the surface of the evaporator tubes to promote rapid boiling and evaporation. The tubes are heated by steam from a thermocompressor feeded by boiler, which is condensed on the opposite side of the tubes. Only a portion of the seawater applied to the tubes in the effects is evaporated. The remaining feed water is collected and fed to the last effect, from where it is removed by a brine pump. The tubes in the various effects are in turn heated by the vapours created in the previous effect. This vapour is condensed to fresh water product, while giving up heat to evaporate a portion of the seawater feed in the effects. This continues for several effects. The remaining seawater of each effect flows to the next effect by gravity through pipes.

Regional Diffusion

- MED-TVC Systems are today planed and build in the Middle East with Unit sizes bigger than 35 000 m^3/d of capacity
- Most of the more recent applications for the MED plants have been in some of the Caribbean areas.

Maturity

- Scaling up Unit Sizes
- Limited Number of Plant Supplier

Typical Investors profile

- IWPP Projects with a bigger capacity, lower O&M costs, higher Investment
- Utilities in the MENA Region and Caribbean

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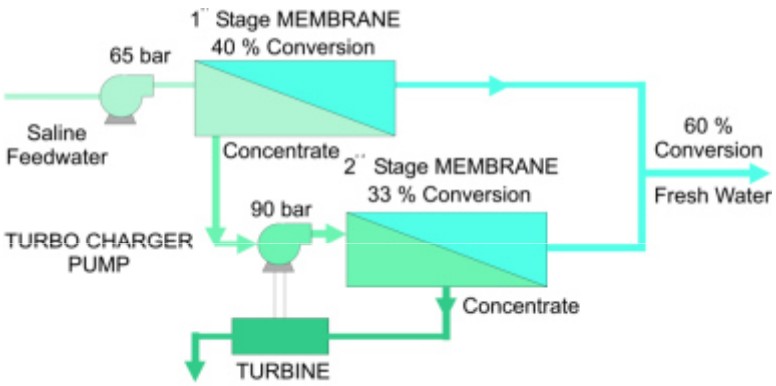
Line Desalination Technology: MED-TVC seems the most promising Desalination Technology

Technology overview



Maturity

- Pre-Treatment is often underestimated
- Energy to be used is only electricity

Technical Description

- RO is a membrane separation process in which the water in a pressurised saline solution is separated from the solutes by making it flow through a membrane.
- The saline feed water is pumped into a closed vessel where it is pressurised against the membrane. As a portion of the water passes through the membrane, the remaining feed water increases in salt content. At the same time, a portion of this feed water is discharged without passing through the membrane. The amount of the feed water discharged to waste in this brine stream varies from 20 to 70 percent of the feed flow, depending on the salt content of the feed water.

Regional Diffusion

- RO Systems are introduced in almost every situation in the world in almost every size
- Especially in the Persian Golf because of a very difficult seawater as feed RO still has a lot of problems. The so fare introduced systems for a sufficient Pre-Treatment have not been standardised yet

Typical Investors profile

- All Type of investments are established around the world

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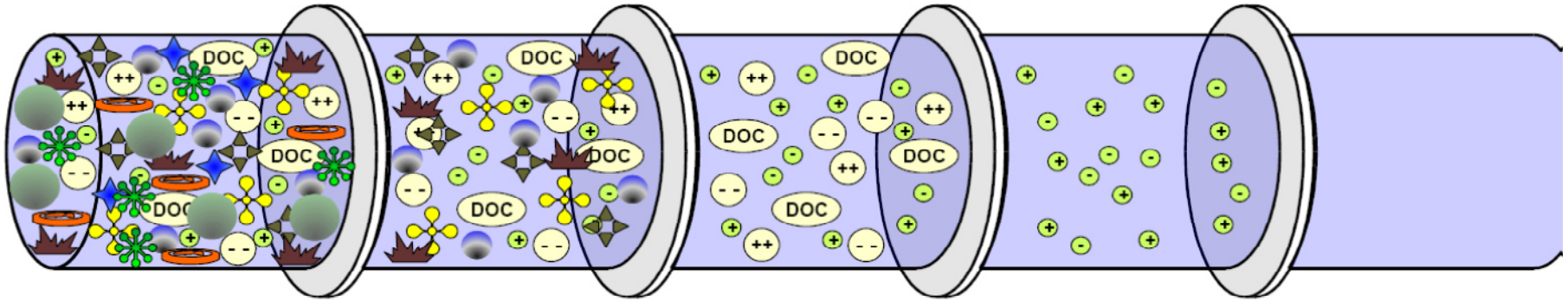
Removal of Water Particles by Membrane



Separated by:	micro filtration > 0,2 µm	ultra filtration 0,1 - 0,01 µm	nano filtration 0,01 - 0,001 µm	revere osmoses < 0,001 µm
Particles in the Water:	zoo plankton algae turbidity bacteria Suspended Solids	macromolecules viruses colloids	DOC organics matter ++ Divalent ions - -	+ Monovalent ions -
required pressure difference:	0,2 - 5 bar	1 - 10 bar	5 - 10 bar	10 - 150 bar

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Comparison of Desalination Processes

	MSF	MED	MVC	RO
Spec. Electrical consumption (kWh/m^3)	2,38 – 3,96	0,75 -1,75	8,5 - 12	2,95 – 5,5
Spec. Steam consumption (kgd/kgs)	0,08 – 0,5	0,1 - 1	0,03 – 0,05	n.a.
GOR (Gained Output Ratio) (kgd/kgs)	2 - 12	1 - 10	20 - 40	n.a.
Spec. Investment (€/m^3/d)	1.000 – 1.600	900 – 1.250	1.100 – 1.300	700 – 1.500

kgs = kg Steam kgd = kg Distillate

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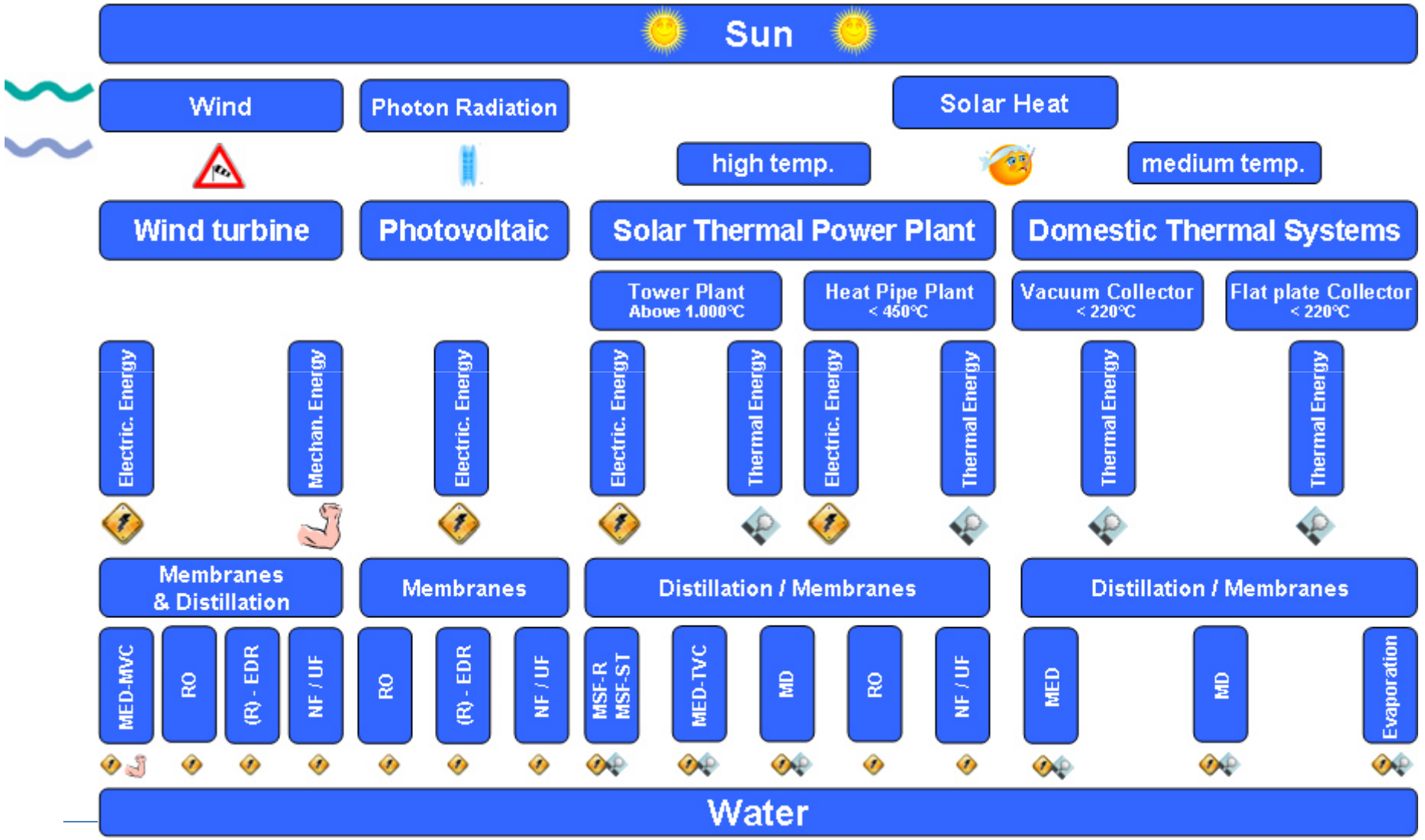
Sun to Water Processes



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Feasibility study including detailed technical descriptions for a MED-TVC Plant, Germany

Site:

Confidential, Germany

Project:

Feasibility study for a MED-TVC plant, Germany (2007)

DME role in the project:

Data collection, feasibility study including detailed technical descriptions for a MED-TVC plant, development and description of possible enhancements of the plant and selected process.

The project aimed at assessing the feasibility of a Multi Effect Distillation plant with Thermal Vacuum Compression at a Confidential location in Germany.

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Technical assistance for establishment of feasibility studies and tender documents, Tunisia

Site:

Provinces of Medenine and Tataouine, Tunisia

Project:

Program for water supply improvement in Southern Tunisia, SONEDE (2008-2013)

The project aims at securing water supply to a total of 7 municipalities in South-East Tunisia under sustainable conditions. Some of the municipalities do already operate desalination plants which ware based on reverse osmosis and electrodialysis including Renewable Energy supply. The studies include the feasibility studies, final design, tendering and tender evaluation for rehabilitation/extension and construction of seawater and brackish water desalination plants

DME role in the project:

Technical assistance for studies and tendering and tender evaluation for desalination plants.
Transfer of know-how related to desalination technologies and elaboration of studies and tender documents as well as quality control for documents elaborated by SONEDE.

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