Salt Partners

Why not turn your salt into gold?

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Salt production world-wide

Salt type	World production
Solar salt	90,000,000 t/y
Rock salt	60,000,000 t/y
Brines	70,000,000 t/y
Total	220,000,000 t/y

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Salt consumption world-wide

Salt user	Salt consumption
Chemical industry	140,000,000 t/y
Food	60,000,000 t/y
Other	20,000,000 t/y

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Main salt uses world-wide

Caustic / Chlorine	38%
Soda Ash	18%
Other Chemicals	3%
Human Consumption	21%
Road De-icing	11%
Other Uses	9%

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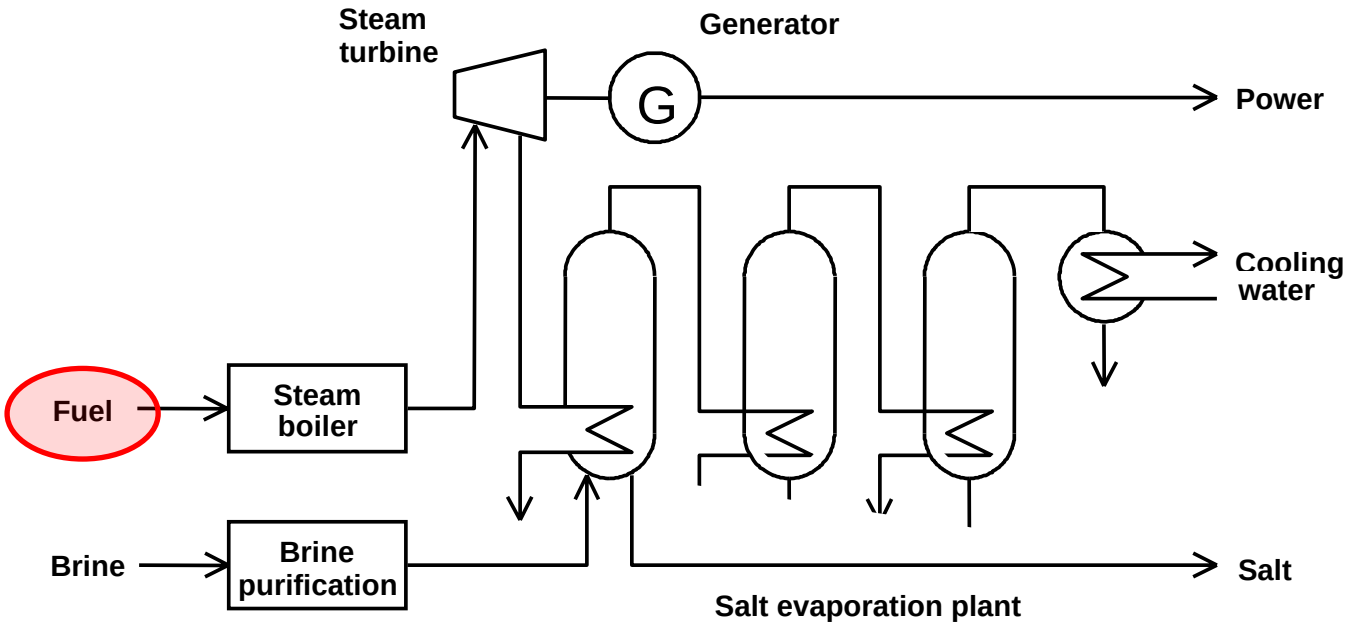
Multiple Effect Crystallisation



Vacuum salt production with cogeneration

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Theoretical prime energy consumption for multiple effect vacuum salt crystallisation

Water evaporation	3 t / t of salt
Steam to first effect	10 bar g
Number of effects	5
Steam consumption	0.75 t / t of salt
Boiler efficiency	90%
Prime energy consumption	450 kWh / t of salt

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Theoretical prime energy consumption for salt crystallisation by thermocompression with mechanical vapour recompression (MVR)

Water evaporation	3 t / t of salt
Power consumption	160 kWh / t of salt
Power generation efficiency	35%
Prime energy consumption	450 kWh / t of salt

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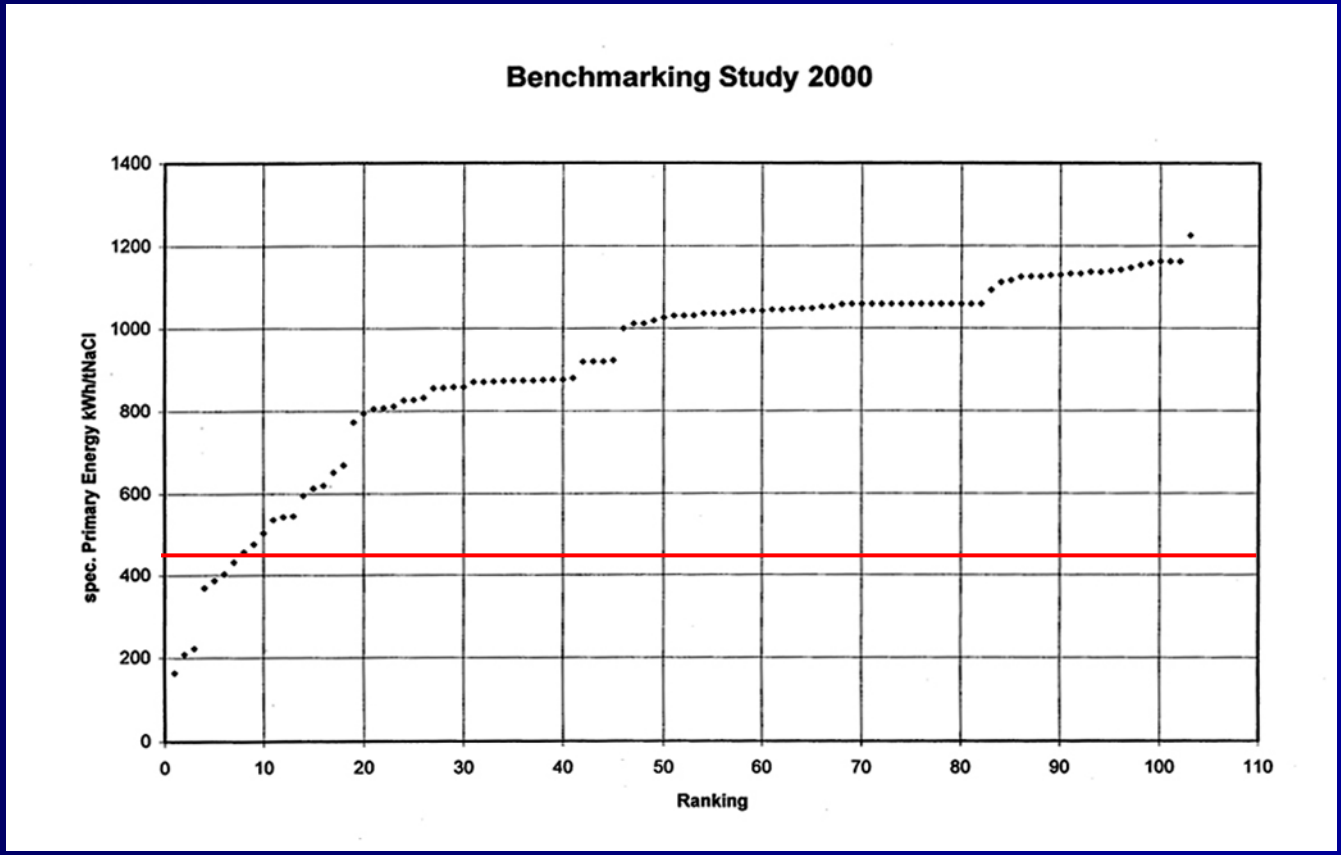
Energy Consumption Benchmarking Study



EVATHERM

96 out of 103 thermal salt evaporating plants surveyed in 2000 used more than theoretical amount of energy

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Actual prime energy consumption for multiple effect vacuum salt crystallisation

Water evaporation	> 3 t / t of salt
Steam to first effect	< 10 bar g
Number of effects	< 5
Steam consumption	> 0.75 t / t of salt
Boiler efficiency	< 90%
Prime energy consumption	**>> 450 kWh / t of salt**

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Why should we be concerned about too high energy consumption in vacuum salt manufacture?

- **Fossil fuel burning**
- **Air pollution**
- **Carbon dioxide emissions**
- **Global warming**
- **Destructive climatic change**
- **Excessive overall cost**

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Air pollution

WU HONG / EPA

Shanxi province supplies black coal to the whole of China

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Global warming

NASA

Hurricane “Katrina” in the Gulf of Mexico on 29.8.2005

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Destructive climatic change

Groenteman

Hurricane “Katrina” destroyed large parts of New Orleans and surroundings

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How much carbon dioxide is being generated when producing energy for vacuum salt production?

1 ton CO2 is generated when producing 1 MWh power in a modern supercritical or ultra critical power station reaching 45% thermal efficiency, fired with high quality black coal having heat of combustion of 7'000 kcal/kg.

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How much carbon dioxide can be saved by replacing vacuum salt with solar salt?

Prime energy consumption in vacuum salt production process	1’000 kWh / ton of salt = 1 MWh / ton of salt
Black coal	1 ton of CO2
Fuel oil	0.7 ton of CO2
Natural gas	0.4 ton of CO2

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What is the value of Certified Emission Reductions?

Current value of Certified Emission Reductions (CER) is

- Approx. EUR 11.- / ton of CO2 equal to
- Approx. USD 15.- / ton of CO2

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How is the profitability of solar salt production effected when replacing vacuum salt with solar salt under the Clean Development Mechanism (CDM)?

Market price of high quality solar salt for chloralkali manufacture	USD 15 - 20 / ton of salt
Profit on salt	USD 3.- / ton of salt
Profit on CER's	USD 15.- / ton of salt
Total profit	USD 18.- / ton of salt

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What are the main conditions for registration of carbon dioxide reduction projects under the Clean Development Mechanism or JI schemes?

- **Additionality**
- **Established baseline**
- **Project Design Document (PDD)**
- **Compliance with Gold Standard or equivalent**
- **Methodology**
- **Monitoring**
- **Etc.**

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How could a solar salt project qualifying for registration under the CDM schemes look like?

- **Identify a chloralkali plant using vacuum salt**
- **Establish a project for solar salt production**
- **Obtain commitments to replace vacuum with solar salt**
- **Elaborate and register PDD**
- **Implement: Produce high quality solar salt**
- **Monitor: Replace vacuum salt with solar salt**
- **Earn, utilise or sell CER's**

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Risks and remedies

Registration approval procedures of Clean Development Mechanism (CDM) and Joint Implementation (JI) projects with CDM Executive Board (CDM EB) under the guidance of Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) approvable by Designated Operational Entities (DOE) in accordance with Project Design Documents (PDD) elaborated according to UNFCCC CDM rules can only be...

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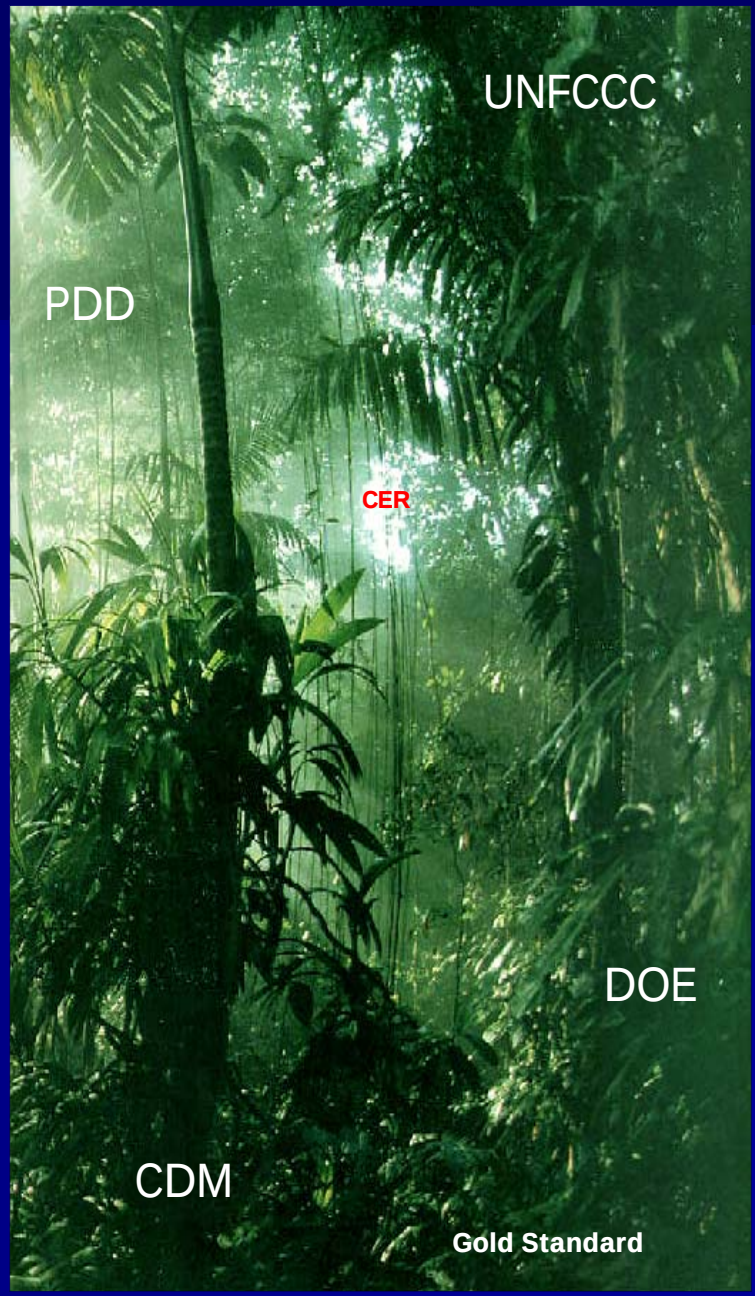

IMART

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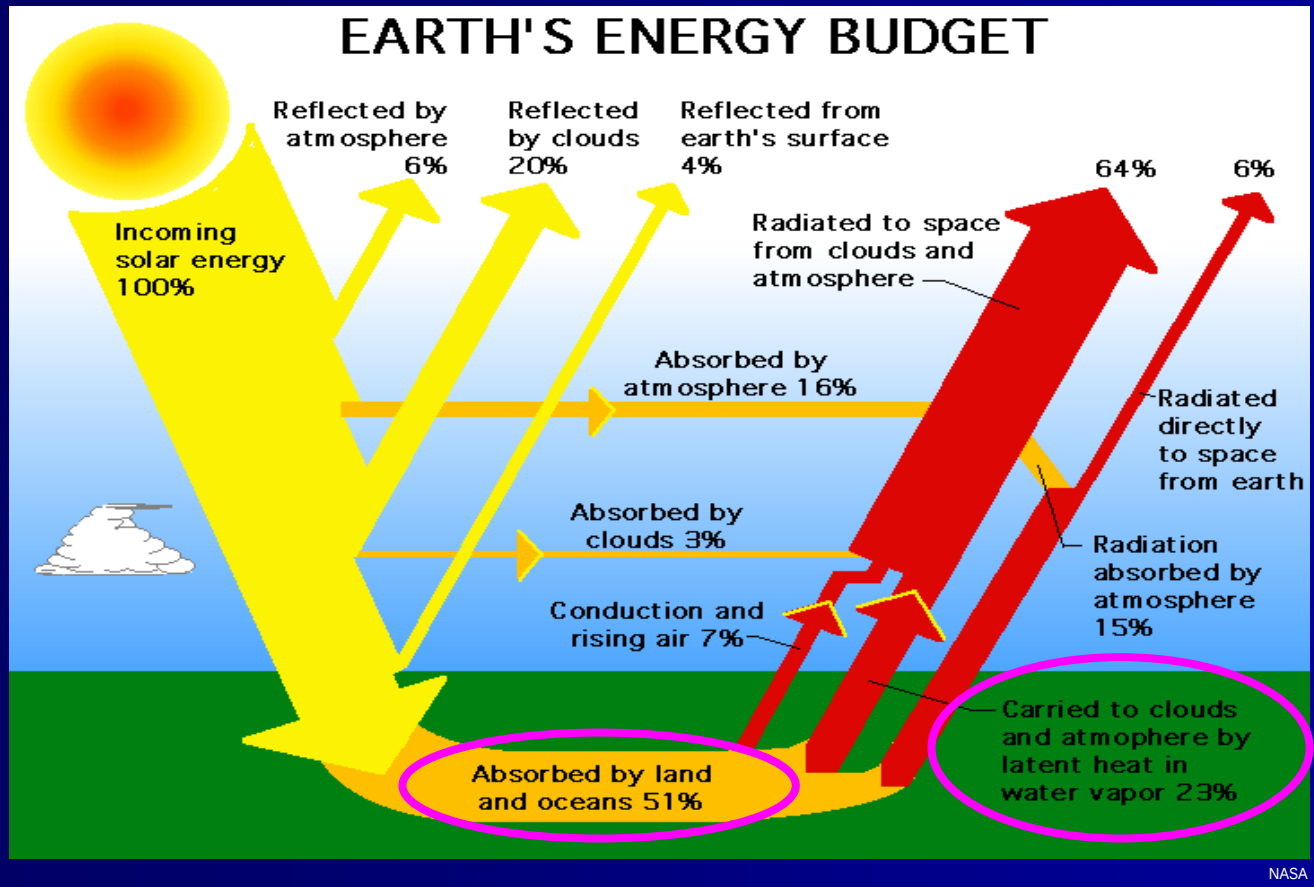
Earth's solar energy budget



Solar evaporation efficiency:

23/51 = 45%

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Conversion efficiencies

Photovoltaic cells	8 – 15%
Solar collectors with stirling engine	30%
Super critical steam power plants	40 – 45%
Solar salt production	45%

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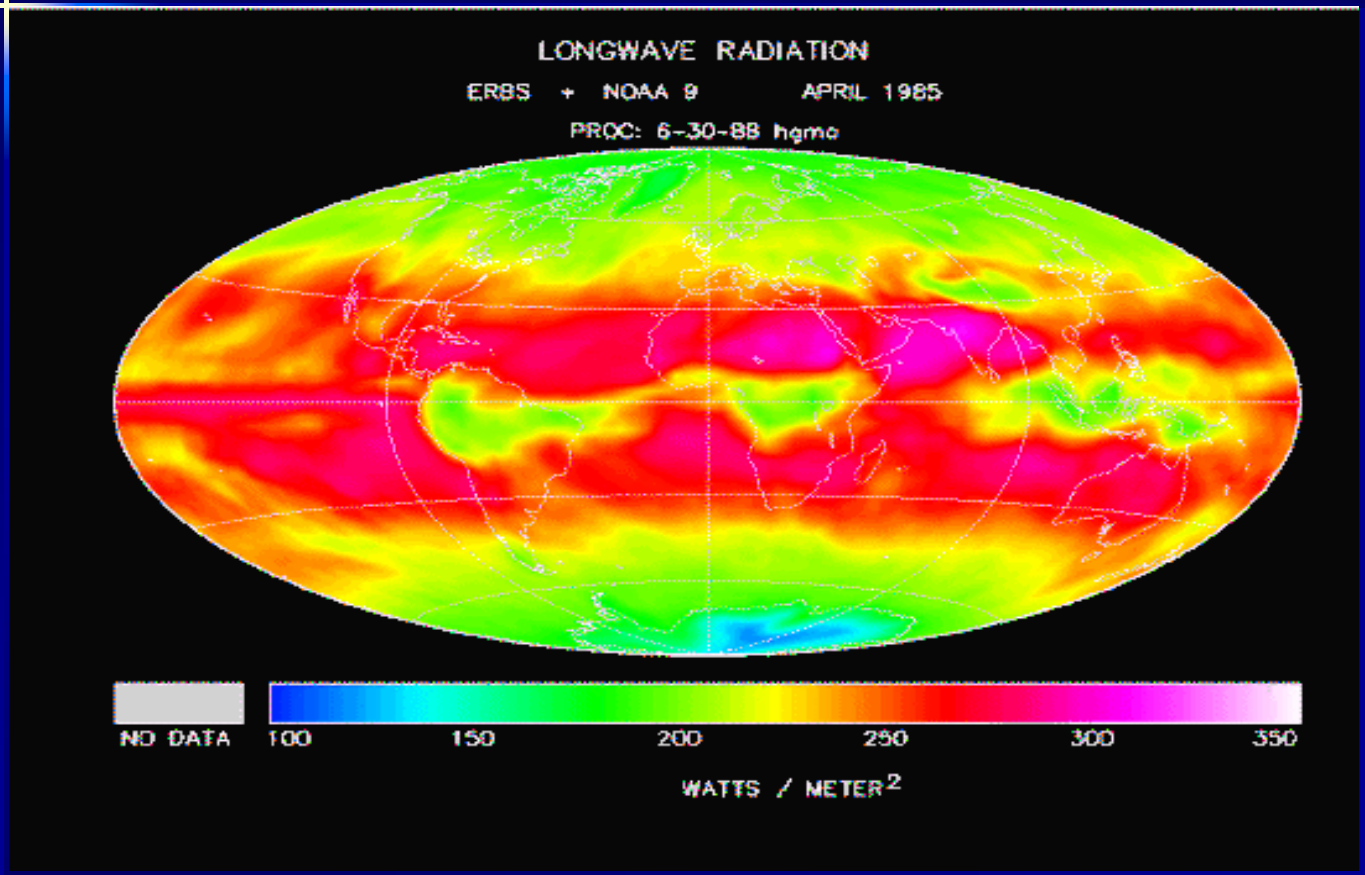
Solar energy on the planet Earth



NASA

Locations with highest rates of evaporation:

Caribbean Sea
NW Africa
SW Africa
Middle East
Western India
Western Australia

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Why must solar salt for membrane cells be pure?

- **Hydrogen evolution**
- **Membrane damage**
- **Incrustations**
- **Contaminated effluents**

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Three saltworks areas that are critical to production of high quality solar sea salt

- **Sea water pre-concentration area**
- **Solar salt crystallisation area**
- **Salt purification plant**

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Sea water pre-concentration area

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What to do and what to avoid in the sea water pre-concentration area

- **Increase concentration gradually, avoid back-mixing**
- **Prevent seepage**
- **Cultivate dark pre-concentration pond bottom**
- **Maintain clear brine**
- **Avoid calcium sulphate over-saturation**
- **Allow nutrients in brine to get consumed**

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Solar salt crystallisation area

- **Employ crystallisers in series**
- **Drain 28.5°Bè brine**
- **Support growth of *Halobacterium* that colours the brine red**
- **Allow thick brine layer to avoid reflection of solar radiation**
- **Avoid organic matter that causes formation of small crystal agglomerates**
- **Harvest under level control to avoid salt contamination with insolubles**

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Solar salt from poorly managed saltworks

Salt that looks like a crystal, but it is an agglomerate.

The agglomerate can be broken by hand.

Impurities are imbedded between the small crystal fragments.

The salt is not well upgradeable.

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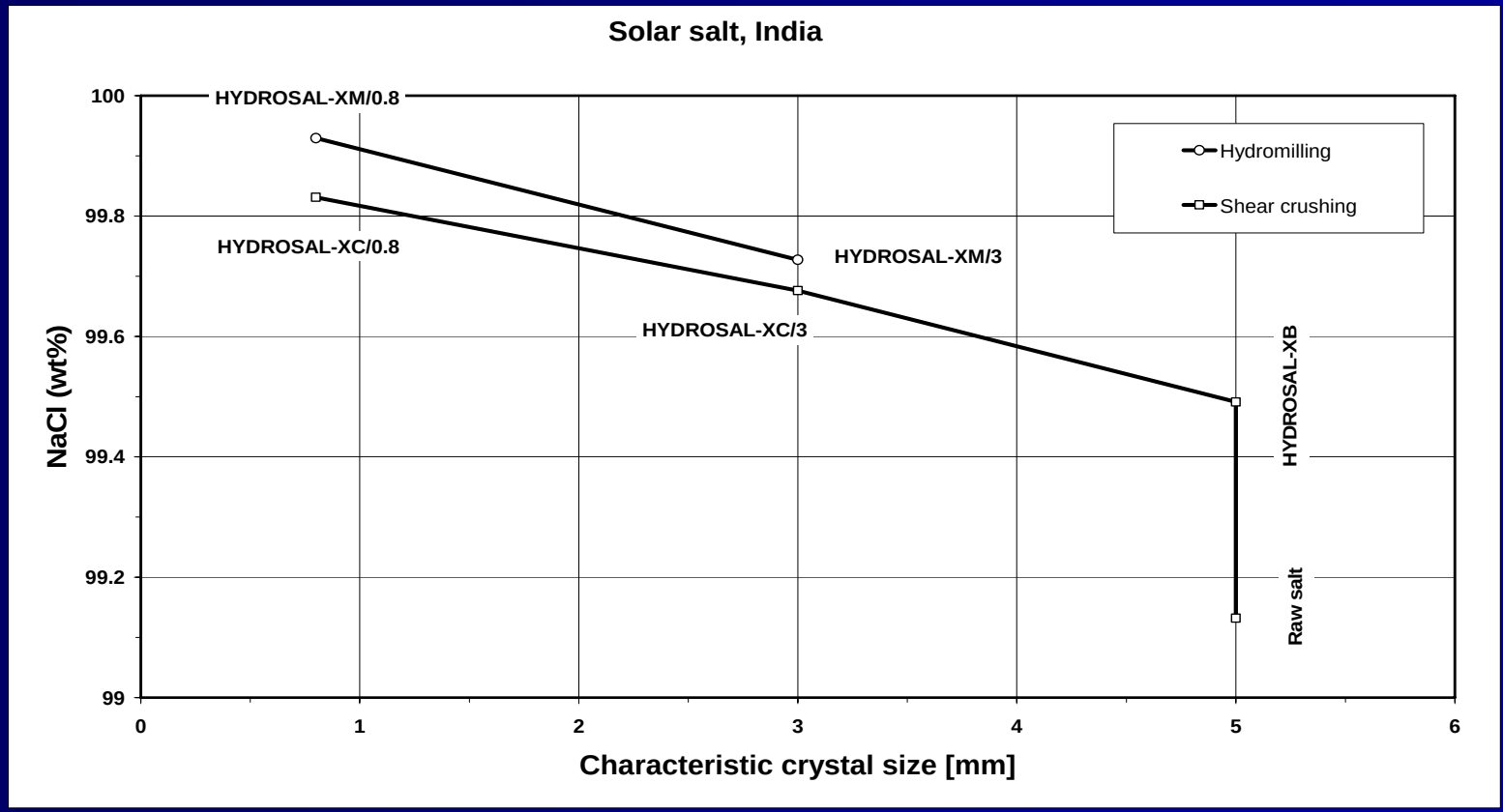
Salt upgradability test, NaCl content



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Solar salt from well managed saltworks

Hard, clear crystal, impossible to break by hand.

Impurities are only on the crystal surface. The salt is very well upgradeable with low losses.

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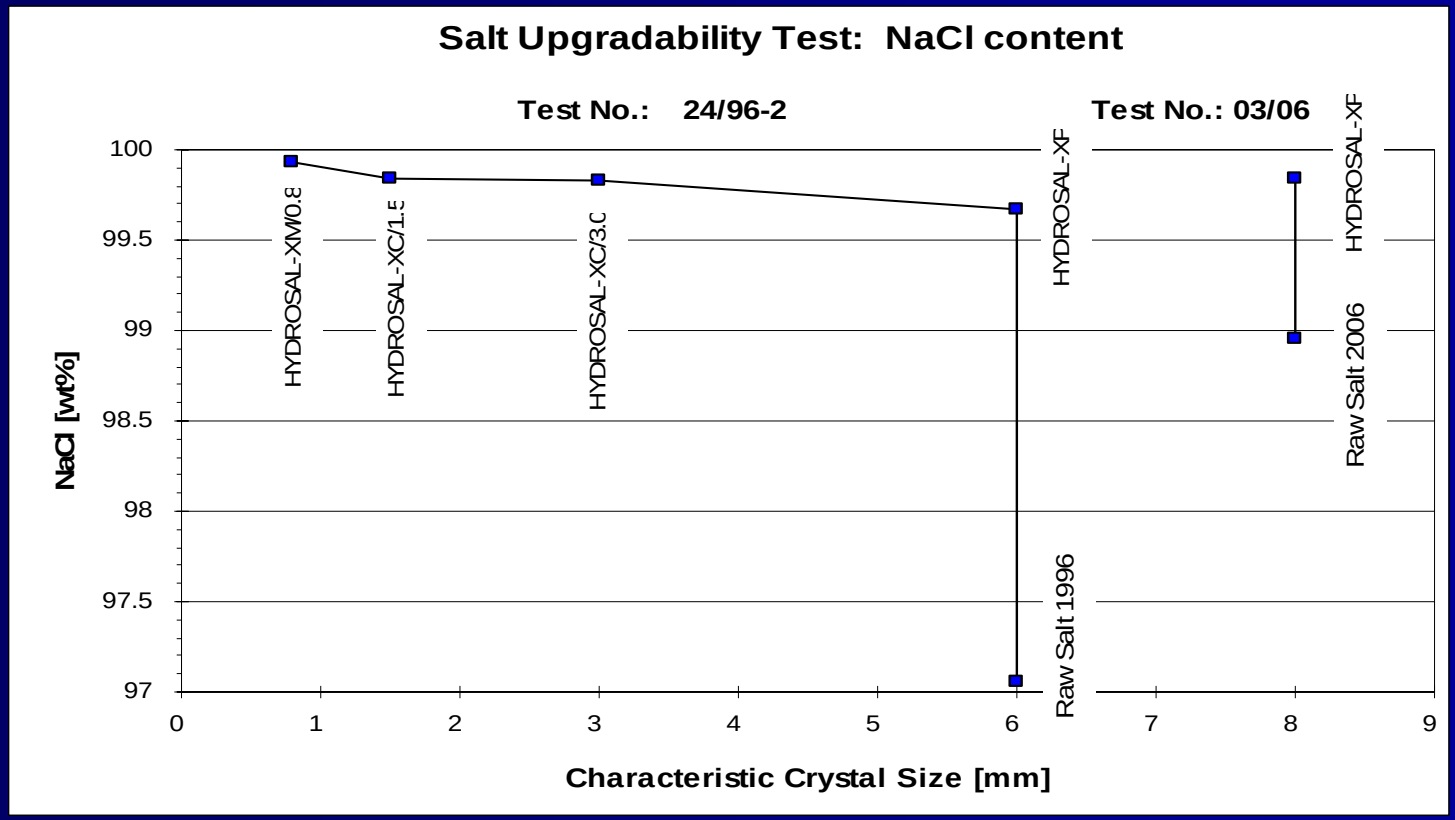
Salt upgradability test, NaCl content



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SALEXPOR 15 t/h solar salt refining plant in Portugal

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100 t/h industrial salt upgrading plant in Spain

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40 t/h salt upgrading plant in Portugal producing purest industrial salt in Europe

		Performance test
Ca	ppm	0.6
Mg	ppm	0.2
SO4	ppm	44

Efficiency	97.4%
NaCl losses	3.9%

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