



Short Path Condensate Recovery

A new tool for water purification

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Topics

- Identifying a Need; Uses and Limitations of Current Purification Techniques
- SPaCeR Technology
- Applications
 - Energy
 - Ethanol production
 - Gas and Oil E&P
 - Food and agriculture
 - Whey separation
 - Beer and spirits production
 - Brackish water desalination
 - Industrial
 - Wastewater treatment
 - Desalination
- Conclusions



Changing the world...One drop at a time

Existing Purification Materials

- Activated carbon
- Cellulosic filters
- Zeolites
- Various polymers
- Sand beds
- Flocculation and filtration using coagulants such as FeSO_4
- Biofiltration

Physical / Electrochemical Methods

- Phase change
 - Flash distillation
 - Freezing
- Ion transport
 - Osmosis (reverse and forward)
 - Electrodialysis
 - Ion exchange



Existing Techniques & Challenges

Technique

- Distillation
- Bed treatment
- Reverse osmosis
- Biological

Challenge

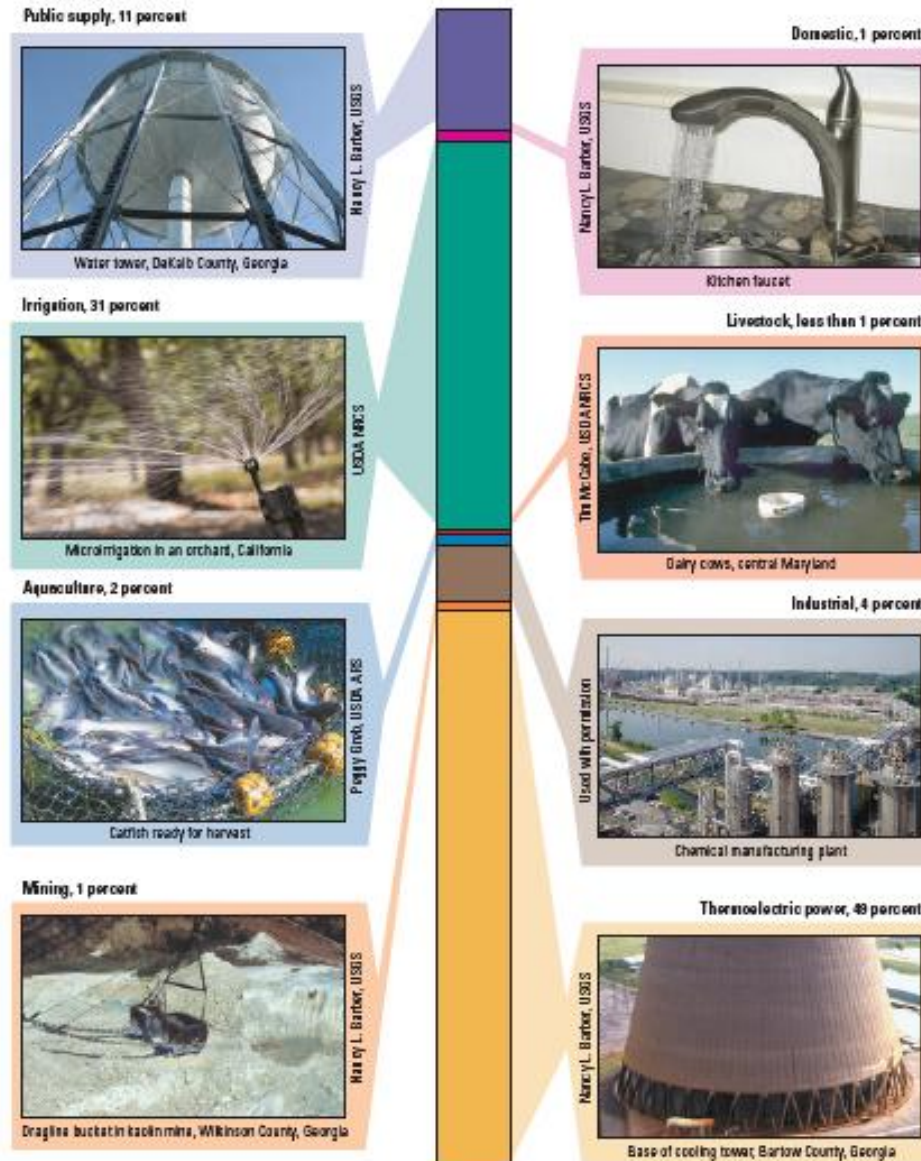
- Energy cost
- Volume, disposal, regeneration, flexibility
- Fouling, energy cost
- Volume, speed, flexibility

Our question – how could we design a simple and robust system that combined

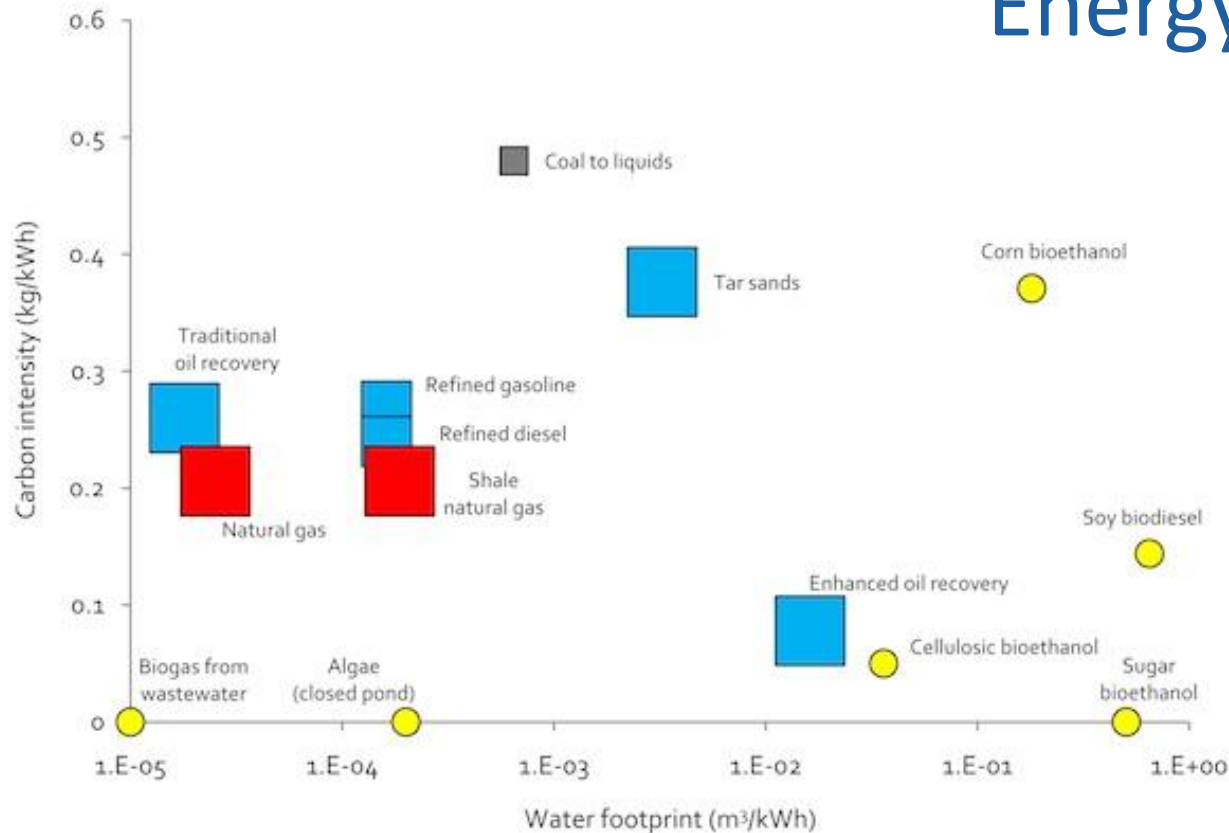
- Low energy consumption (preferably using waste heat)
- Compact footprint
- Ease of use
- Ionic / nonpolar / organic / inorganic compatibility

And could provide a stream separation of water and concentrate so that water could be reused and concentrate could be refined or cost-effectively disposed.

Where Is The Need?



Energy is a Big User – Does Alternative Energy Help?



Not exactly...

Lux Research, 2010

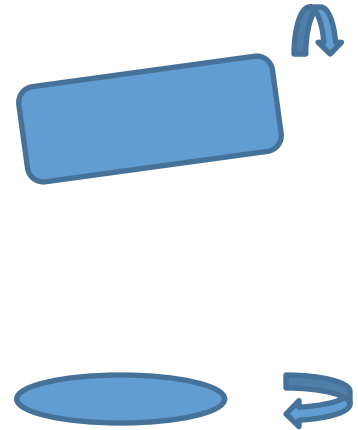
We Like Distillation - But



- Distillation is a low thermal efficiency unit operation that currently consumes 4.8 quadrillion BTUs of energy—40% of the processing energy used in refining and continuous chemical processes.
- The multiphase gas/liquid flow patterns in distillation columns are complex, making them difficult to predict and control.
- Lack of understanding of the mass transfer and flow dynamics occurring between phases inside these devices is the primary barrier to improving their energy and process efficiencies.

Genesis of The Solution

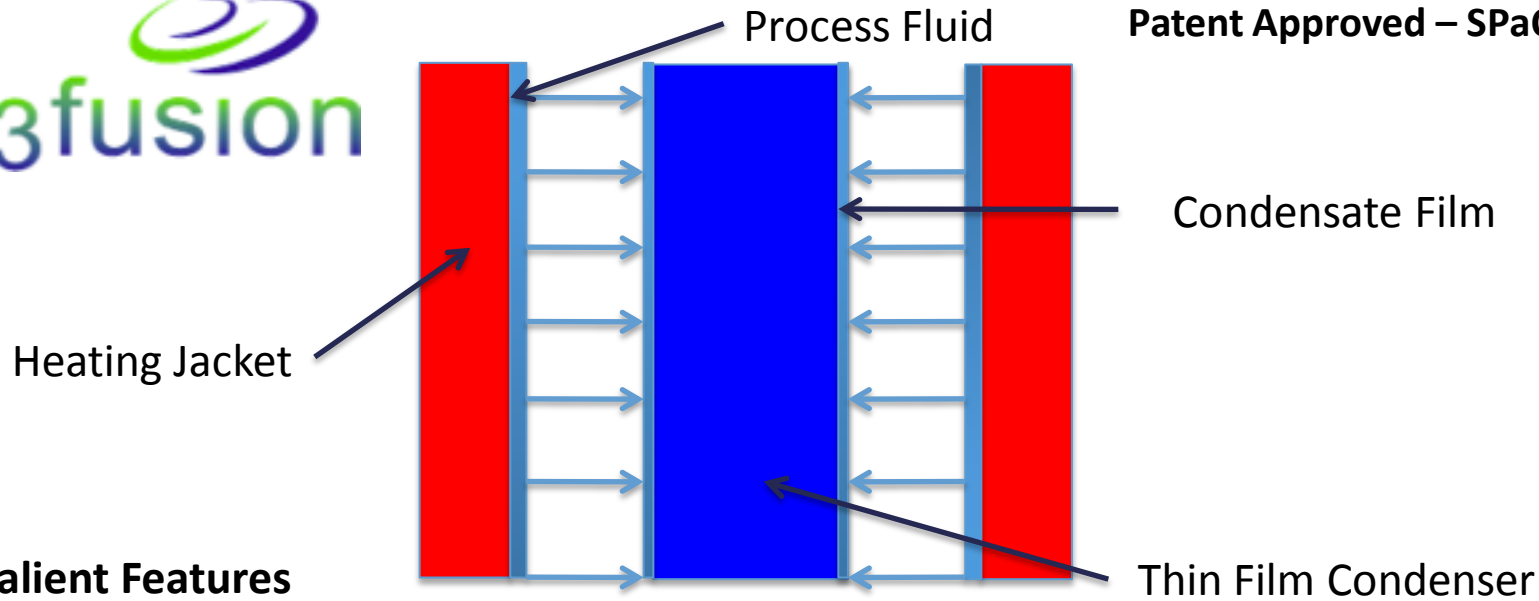
- Process Intensification
 - Using ultra thin films of liquid for highly effective processing
 - Gas-liquid
 - Liquid-liquid
 - Reactive thin films can be generated in a number of ways
 - Spinning discs, rotating cylinders
 - Effective but can be mechanically challenging
 - The new SPaCeR configuration
 - Novel but mechanically robust construction
 - Patent publishing soon
 - **Short Path Condensate Recovery**



Dr. Roshan Jachuck

SPaCeR™

- Advantages over existing methods
 - Lower energy balance
 - Can use waste heat
 - Economic where other processes are not
 - Easy cleaning
 - Scalable
 - Reconfigurable units
 - Can be combined with other purification techniques e.g. UV to yield potable water



Salient Features

- Negligible vapor pressure build-up – due to short condensation path length
- Thin film heat transfer on evaporation & condensation surfaces gives a high heat transfer coefficient
- Unique distribution system for maintaining the thin film on both the heating and cooling side allows uniform temperature distribution and minimizes scaling
- High surface area density due to the use of tailored / profiled heat transfer surface and jacket design; heat transfer material can be tailored to enhance chemical resistance
- High thermal conductivity material with thin sections used for reducing the resistance offered by the heat transfer surface.
- Vacuum capability to achieve high overall heat transfer coefficient.

R3 Fusion Comparison to Distillation & RO Technologies

Description	Distillation	Reverse osmosis	SPaCer
Energy kWh/m ³	17	5	<5
Energy source	Heat	Electrical pumps	Flexible
Maintenance	High	Moderate	Low
Water TDS mg/l	0.5-50	50-500	50
Modularity	No	Yes	Yes
Best application	Seawater / cogen / industrial	Flexible	Flexible
Cost ratio	1.9X	1.8X	1X (desalination)



Changing the world...One drop at a time

Application Space ~85% of Water Use

- Energy
 - Biofuels
 - Frac water, slop water, completion fluids, produced water
- Agriculture
 - Desalination
 - Food processing
- Industrial



Energy Industry I – Ethanol production

- Extracts ethanol from process water
 - Increased fermentation yield by removing ethanol from recyclable water
- Compatible with any fermentation method
 - Corn, sugar cane, sugar beet, cellulosic...

Recovery of Ethanol from Process Water



Energy Industry II – Drilling fluids

- Impure water is expelled from gas and oil wells and must be treated
- Impurities in oil / gas water include BTEX and a wide range of process chemicals
- Increasing restrictions are coming on discharge and aquifer contamination
- Will become a bigger issue as we increasingly rely on natural gas in the USA

Oil E&P Water Treatment

Scalable
Vacuum Capable
High Thermal Efficiency



Food and Agriculture - I

- Concentration of whey from cheese making
 - Used as a diet supplement for humans and animals
 - Removing water by other methods is cost prohibitive



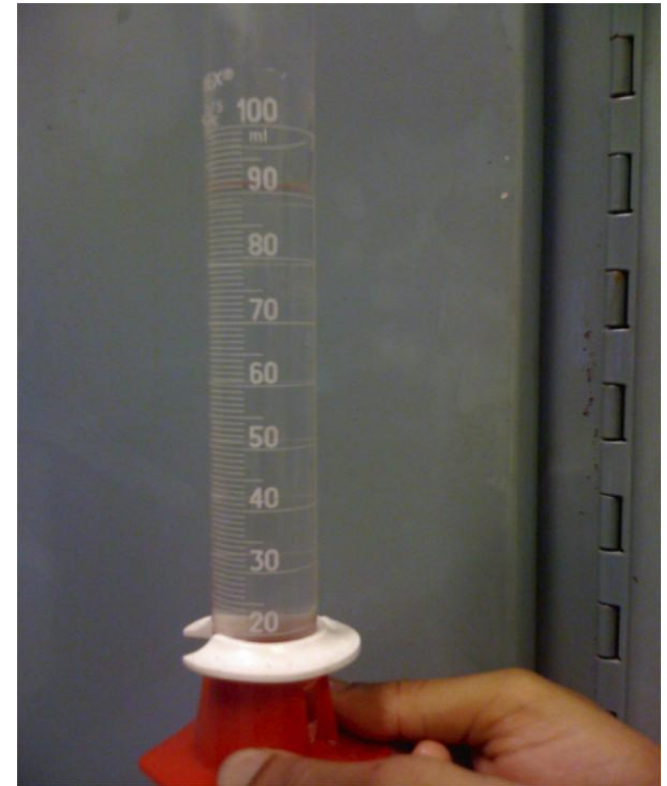
Cheese-Making Whey



97% water



SPaCeR



Recovered water usable in boiler

Food and Agriculture II

- Alcohol isn't just a fuel...
 - Any fermentation or distillation process that recycles water will benefit from this process
 - Modular units are adaptable to micro breweries and large production units
- Desalination to make brackish water usable for agriculture

Industrial

- Removal of contaminants from water

Or

- Removal of water as a contaminant
- Separation from inorganic or organic contaminants with an energy advantage over distillation, RO and other techniques

Business Model

- Identify **markets** where existing technologies are struggling
- Develop scalable technical **solutions**
- Develop appropriate **partnerships** to address market access and scheduled maintenance
- Real time **performance** monitoring to ensure uptime
- Develop appropriate **revenue** models including capital-free revenue sharing

Making it Easy for Clients



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