U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Breakout Sessions Report

2017 Clean Water Technology Workshop
Dallas, TX

Advanced Manufacturing Office

www.manufacturing.energy.gov

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Group 1: Water Purification
Breakout Session 1: Membrane-based Technologies

Opportunities and Targets

- Highly selective membrane (specific ion/contaminant removal, divalent vs. monovalent)
- Fouling, scaling resistant
- Contaminant resistant (e.g., Chlorine, bromine)
- Easily regenerated
- Able to be stored dry between deployments
- Real-time monitoring / Automatic defect detection
- Stable operation in harsh conditions: T, P, chemistry
- Catalytic membranes

Group 1: Water Purification
Breakout Session 1: Membrane-based Technologies

Technology Barriers/Challenges

- Pilot scale test bed
- Selectivity of ions, contaminants (e.g., mono- versus di-valent ions)
- Understanding trade-offs in TDS/pathogens/chemicals by application
- Overall energy use

R&D Needs

- Techno-economic consistency (e.g., well-defined metrics: what's included in energy/cost/… and what is not?)
- Brine management
- Molecular modeling/Characterization to understand membrane formation and structure
- Molecular modeling to understand behavior of water in confined spaces
- Characterization to understand membrane formation and structure (Imaging/spectroscopy)
- Membranes with tunable selectivity/permeability and responsive to environmental/operating conditions (pH, light, salinity)

Group 1: Water Purification
Breakout Session 2: Non-Membrane/Thermal Technologies

Opportunities and Targets

- Electrochemical recovery of valuable components
- Scale resistant technologies
- Thermal system integration with existing processes (e.g., low grade heat recovery)
- 3D printed novel heat exchangers
- Reusable materials capable of selective ion removal
- Waste nuclear heat utilization for desalination
- Metric: *kW/mol salt removed*

Group 1: Water Purification
Breakout Session 2: Non-Membrane/Thermal Technologies

Technology Barriers/Challenges

- Inexpensive material for selective ion removal
- Improved scale inhibition
- Distributed/modular approaches
- Pilot plant access
- Ability to efficiently recover low temperature gradient heat
- Lack of water and energy metrics

R&D Needs

- Database of impaired waters and heat sources (Geospatial/amounts/quality)
- Hybrid technologies / process intensification
- Understanding thermodynamics of high salinity aqueous solutions
- Highly selective FO membranes/MD membrane optimization

Group 1: Water Purification
Breakout Session 3: Pre-treatment Processes

Opportunities

- Techniques and standards for biofouling potential and treatment
- Non-chemical methods of scaling inhibition
- Dynamic, reusable flocculants
- Selective contaminant removal: photo and electrolytic processes. adsorption
- Ability to seasonally adapt: red tide algae bloom, etc.
- Low energy micro-particle removal

Targets

- GIS heat map of injection or evaporation costs
- Treatment costs less than costs of disposal
- Increase cycles at inland groundwater cooled power plants to >15
- 100% produced water reuse

Group 1: Water Purification
Breakout Session 3: Pre-treatment Processes

Technology Barriers/Challenges

- Fundamental understanding of fouling and biofouling, especially biofilms
  - Removal of biodegradable organics
- Real-time sensing and pretreatment response

R&D Needs

- Biofouling sensing
- Tech to market analysis for pretreatment alternatives
- Predictive models that include separation, reaction, fluid mechanics, fouling based on complex water source inputs
- Membranes stable to pH, temperature, oxidant, and organics
- Self-cleaning interfaces
- Standardized fouling/scaling potential tests for emerging membrane technologies
- Fundamentals of DLVO theory in high ionic solutions and organic carbon

Group 2: Water Purification
Breakout Session 1: Membrane-based Technologies

Targets

- Performance (includes efficiency, reliability)
  - Increased lifetime
  - Increased stability, robustness
- Cost
  - Moving target, such as $500 acft
  - Up to 4x system reduction of cost compared to what is currently available
- Energy
  - Up to 3x reduction of electricity use compared to what is currently achievable
- Environmental
  - Up to 2x reduction of greenhouse gas compared to what is currently achievable

Technology Barriers/Challenges

- Coating technologies for low cost ultrathin membranes with low defect concentration

R&D Needs

- New materials for CDI (capacity deionization) and MCDI (membrane deionization) including brackish water
- Flexibility of material properties tolerant to organics, hydrocarbons, high temperatures, and ions
- Better understanding of solute interactions with membranes surface and pores, e.g. ion transport/storage, chemical interactions, interfacing confined spaces and pores

Group 2: Water Purification
Breakout Session 2: Non-Membrane/Thermal Technologies

Targets

- 60% of energy is waste heat, what percentage of this is available for 3 year industry payback?
- Levelized cost of energy equivalent to grid or less
- Mineral recovery as a resource for potentially critical materials

Technology Barriers/Challenges

- Lack of high profile, field demonstrations that integrate existing technologies and validate to end users deployment
- Lack of understanding of evaporation mechanisms at molecular level

R&D Needs

- New materials and surfaces as well as process optimization to reduce fouling and improve system uptime
- High efficiency heat exchangers with long-term, stable performance
- Thermally regenerated desiccants, e.g. iconic liquid

Group 2: Water Purification
Breakout Session 3: Solar-thermal Power/Desalination Integration

Targets

- Collector cost targets– temperature dependent and capacity dependent
  - Range was $50 - $100 per m^2
- Levelized cost of solar desal must be competitive with conventional methods
- Zero liquid discharge
- Integrated PV and solar thermal to optimized systems

Technology Barriers/Challenges

- Scaling/Fouling, especially at high temperature, greater than 300^C
- Lack of software/optimization tools to guide decision making, especially for small businesses
- Lack of understanding of how to cascade system design

Group 2: Water Purification
Breakout Session 3: Solar-thermal Power/Desalination Integration

R&D Needs

- Materials: heat transfer fluids; cost effective, corrosion resistant materials
- Storage: cost effective low temperature energy storage; transportable storage
- 1MW$_t$ or less: cost effective systems at this range
- Integration of solar pretreatment and solar desal
- Use desal for waste heat/cooling at CSP plants

Group 3: Water Systems Integration
Breakout Session 1: Sensors and Controls

Opportunities and Targets

- Measurement speed – should match process/equipment dynamics, will depend upon goals (Though about 15 minute data should be sufficient)
- Advanced sensor analysis – explore using existing real-time, coupled sensors
- Sensors, controls, and algorithms/data for renewable/conventional energy integration (real-time simulation)
- Rapid go/no-go to detect composition change, direct new incoming streams, detect contaminants

Technology Barriers/Challenges

- Low cost sensors; selectivity with different TDS types; self-healing, self-correcting (7)
- Main processing challenge to address: fusion of multiple measurements in real-time (6)
- Sensors need to be designed within new components/technologies, as part of manufacturing (help support troubleshooting more efficiently) (6)

R&D Needs

- Renewable integration, including solar, thermal, waste heat, PV, wind, hydrogen; load profile modeling and deploy solution (13)
- Relationship between sensors in a sensor network will tell us faster if failure is imminent and define a fault attribution (13)
- Network design: approaches to design “optimal” sensor network in time and space (7)

Group 3: Water Systems Integration
Breakout Session 2: Water Intake, Transport Engineering, Effluent Handling and Conc.

Technology Barriers/Challenges

- Fit for purpose treatment (depending upon industry, crop, etc.) (16)
- Decentralized systems to prevent transport losses (modular systems would reduce need to transport) (12)
- Identifying leakage points in distribution systems is a challenge (7)

R&D Needs

- Flexible, modular systems are needed for distribution/ treatment (plug & play); different technologies for different uses (9)
- Materials for specific adsorption, selective separations (5)
- Sensors and telemetry for infrastructure and equipment monitoring/diagnostics (4)

Breakout Session 3: Water Purification Plant Design and O&M
Group 3: Water Systems Integration

Opportunities and Targets

- Modular plants:
  - Locally for brackish groundwater desal; integrated & distributed stormwater management; WRRFs; produced water, selective contaminant removal
  - To lower manufacturing costs, increase resilience
  - As additive treatment modules to simplify plant design, one-size fits all plant design
- Co-location:
  - Offers additional benefits, e.g., energy reduction using waste heat & energy storage through water storage
    - Tools to enable fit-for purpose water markets e.g. WaterSage, DigitalH2O
  - Jointly plant and design water purification/energy plants (not join them together after design) to enable DER/grid services to be supplied by water system, using forecasting and controls
- Must recognize that policy and regulatory changes can affect cost reduction on the same order as technical improvements

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