# ARPA-E Emerging Ideas Workshop:
## No- and Low-Water Power Plant Cooling

March 28, 2012
8:00AM – 3:30PM
Offices of ARPA-E
955 L'Enfant Plaza, North Building, Suite 8000 (8th floor)
Washington, DC 20024

### Objective

Identify key needs and potentially transformational technological approaches for

1. Enabling dry cooled power plants to attain equal to or better efficiency than wet cooled power plants; and
2. Enabling Gigawatt-scale dissipation of low grade heat (35° C) to air without evaporating water or raising surface water temperature.

### Introduction

Thermoelectric power plant cooling currently accounts for 50% of U.S. water withdrawals. This water is almost entirely withdrawn from fresh and saline surface water. Power plants use this water by evaporating it (closed loop cooling) or by heating it to a higher temperature before discharging it back to the surface water source (open loop or once-through cooling). Dry power plant cooling, where the air is heated without evaporating water or raising surface water temperature, is technically proven but remains an option of last resort because it is more expensive up front and it reduces power plant electricity output by ~6-16% compared to wet cooling, depending on time of year. This is because dry cooled steam condenser temperatures, which determine turbine back pressure and thus efficiency, are higher midday during peak load than wet cooled steam condenser temperatures. Specifically during peak load, dry cooled condensers run at the daytime dry bulb air temperature which is higher than the 24-hour average wet bulb temperature that open loop wet cooled condensers approximately operate at. However, properly designed dry cooling systems, for example incorporating thermal diodes and thermal storage such as water to source and sink heat into, could make it possible to achieve comparable or possibly better performance by attaining the nighttime dry bulb air temperature, which is colder in some geographies.

**Why Now:** U.S. electric power providers will adopt inferior performance dry cooling over time for two reasons. First, the U.S. population is projected to grow 30% by 2030, and mostly in hot areas without water like California, Arizona, Texas, and Florida. Second, recent legislation, Clean Water Act §316(b), calls for power plants to cool using the "best technology available" in order to reduce direct physical harm to aquatic animals, eggs, and larva and to reduce environmental damage caused by insufficient water levels and elevated water temperatures. This legislation will push power plants to use closed loop cooling where water is available for evaporating and dry cooling where it is not.

**Potential Impact:** Improved efficiency dry cooled power plants and gigawatt-scale dissipation of low grade heat (95° F) to air without evaporating water or raising surface water temperature, dry cooling, is a crucial impending technology need for the United States and world. Presently it is used for cooling thermoelectric power plants in water scarce regions like the U.S. Southwest, western China, and the Middle East. As water scarcity increases this use will spread geographically and to new cooling applications like chemical and petrochemical refineries, factories, data centers, and greenhouses. On longer time scales, climate change adaptation is largely considered to be water adaptation, to increased droughts and flooding. Under such scenarios dry cooling methods decoupling electricity production from water supply will be highly valuable. For concreteness, this workshop focuses on advanced dry cooling for power plants.

## Agenda

| Start | End | Activity |
|---|---|---|
| 8:00 | 8:15 | Registration & Breakfast |
| 8:15 | 8:30 | Welcome & Opening Remarks – Nicholas Cizek, ARPA-E |
| 8:30 | 8:50 | Power Plant Cooling – Olivier Le Galudec, Alstom |
| 8:50 | 9:10 | Dry Power Plant Cooling State of the Art – John Maulbetsch, Maulbetsch Consulting |
| 9:10 | 9:30 | Electronics Cooling State of the Art – Howard Davidson, Consultant |
| 9:30 | 9:45 | BREAK |
| 9:45 | 11:45 | Brainstorm – Technologies Enabling Dry Cooled Power Plants with Wet Cooled Power Plant Efficiencies or Better |
| 11:45 | 12:45 | Lunch & Review Morning Brainstorm |
| 12:45 | 2:45 | Brainstorm – Dissipating GW-scale Low-grade (35° C) Heat to Air Without Evaporating Water or Raising Surface Water Temperature |
| 2:45 | 3:00 | BREAK |
| 3:00 | 3:30 | Review Afternoon Brainstorm & Wrap-Up |

## Morning Brainstorm

Identify key needs and novel potentially transformational power plant concepts, designs, and materials enabling dry cooled power plants to exceed or meet the efficiencies and low steam condenser temperatures of surface water cooled power plants. Possible approaches include

- incorporating thermal storage to enable passive cooling at night time air temperatures; and
- Incorporating night time ice production for cooling steam condenser cooling water during peak day time loads.

Distill the opportunity into a set of relevant techno-economic metrics – impactful if met, technically audacious, and potentially achievable.

## Afternoon Brainstorm

Identify key needs and novel potentially transformational to-air heat exchanger concepts, designs, materials, and manufacturing processes enabling GW-scale dissipation of low-grade heat (35° C) into air without evaporating water or raising surface water temperature, for example by:

- Increasing surface area (thermally conducting polymers, metal foams, etc.)
- Increasing the to-air heat transfer coefficient (coatings, nanostructures, etc.)
- Efficiently increasing passive or forced convective air flow rate (thermosiphoning, Venturi effect, etc.)
- Reducing parasitic load (thermosiphoning, Venturi effect, etc.)

Distill the opportunity into a set of relevant techno-economic metrics – impactful if met, technically audacious, and potentially achievable.

## Not Discussed

**In the interest of time, the following topics <u>will not be discussed:</u>**

1. Regulations, policies, subsidies and demonstration projects with existing technologies
2. Incremental improvement strategies to existing technologies
3. Ideas that only accelerate down existing learning curves