Turbine Inlet Air Cooling: A Great Strategy for Maximizing the Potential of Combustion Turbines and Addressing the Needs of Restructuring Energy Market

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TAS™ TURBINE AIR SYSTEMS

Avalon Consulting, Inc.
Natural Gas & Power Technology Services

Impacts of Current and Future Restructured Energy Markets

- Offer potential for lower energy costs for consumers
- Challenge producers to reduce cost of electric energy production
- Increase potential for greater price and service volatility
- Increase potential for high electric prices and service interruption due to lower reserve margins

Primary Benefits and Shortcomings of Combustion Turbines

Benefit

- Lowest Installed Capital Cost
- Quick to Market
- Environmentally Friendly

Shortcomings

- Power output decreases as outdoor air temperature increases
- Fuel utilization efficiency decreases as outdoor temperature increases

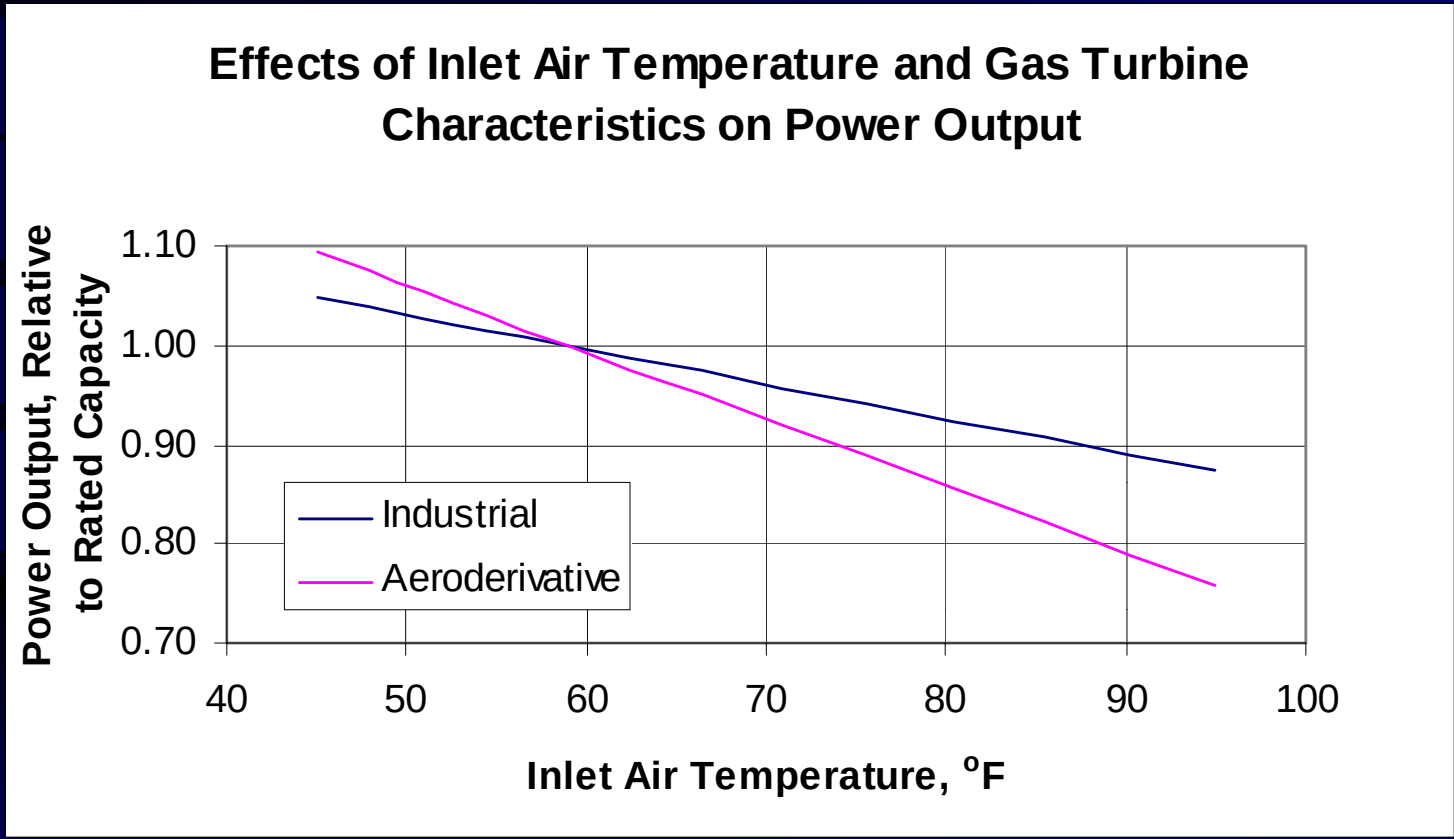
Combustion Turbine Inlet Cooling (TIC) May be the Best Option for Power Plant Owners/Operators

As ambient temperature increases power output and fuel utilization efficiency of a combustion turbine decrease.

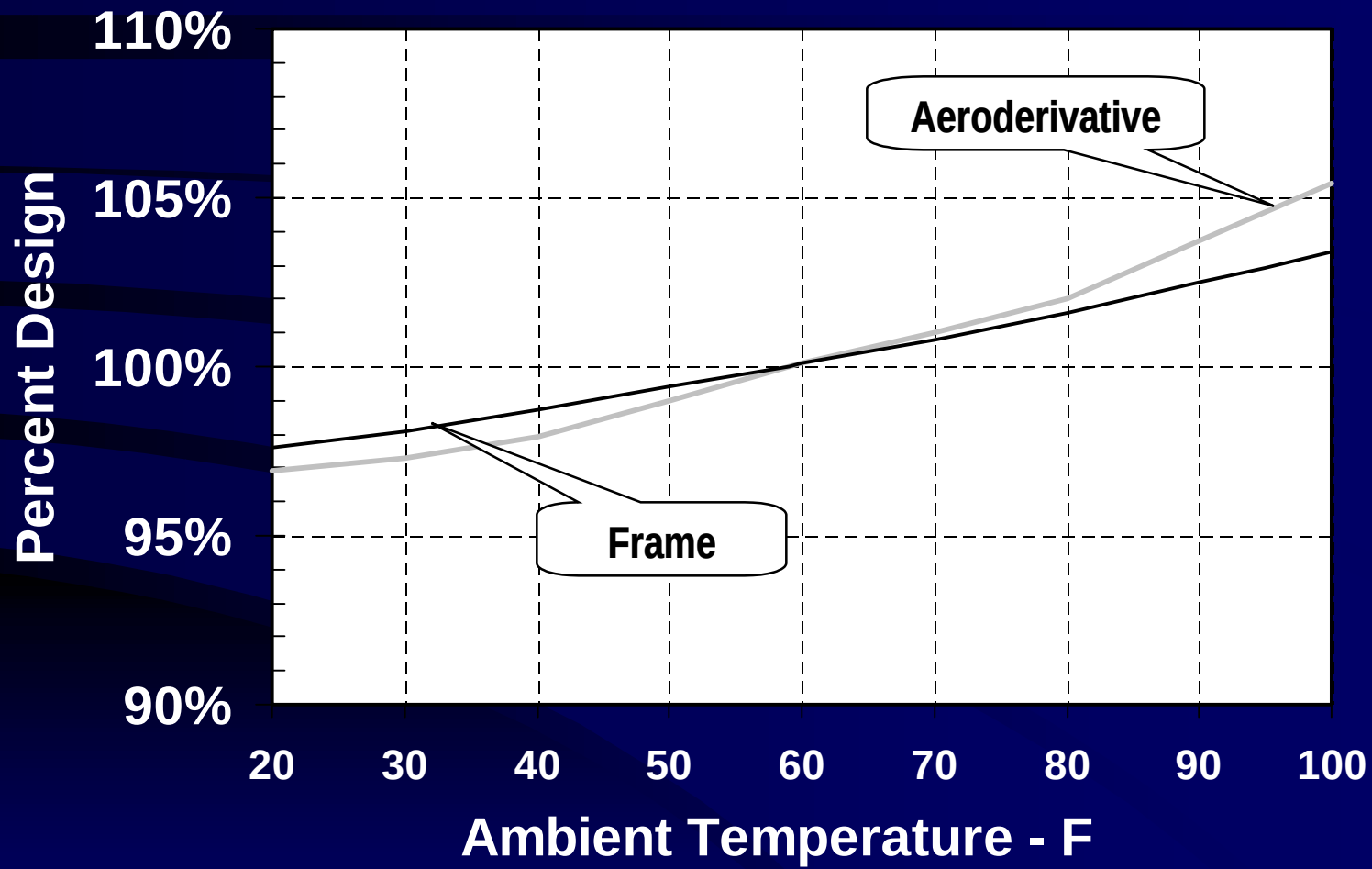
TIC helps maximize the potential of combustion turbines:

- Prevents drop in power output and fuel utilization efficiency
- Allows even increase in power output and fuel utilization efficiency beyond the ISO ratings
- Reduces environmental emissions per kWh of electric energy

Effect of Outdoor Ambient Temperature on Output Capacity of Combustion Turbines



Effect of Outdoor Ambient Temperature on Heat Rate of Combustion Turbines

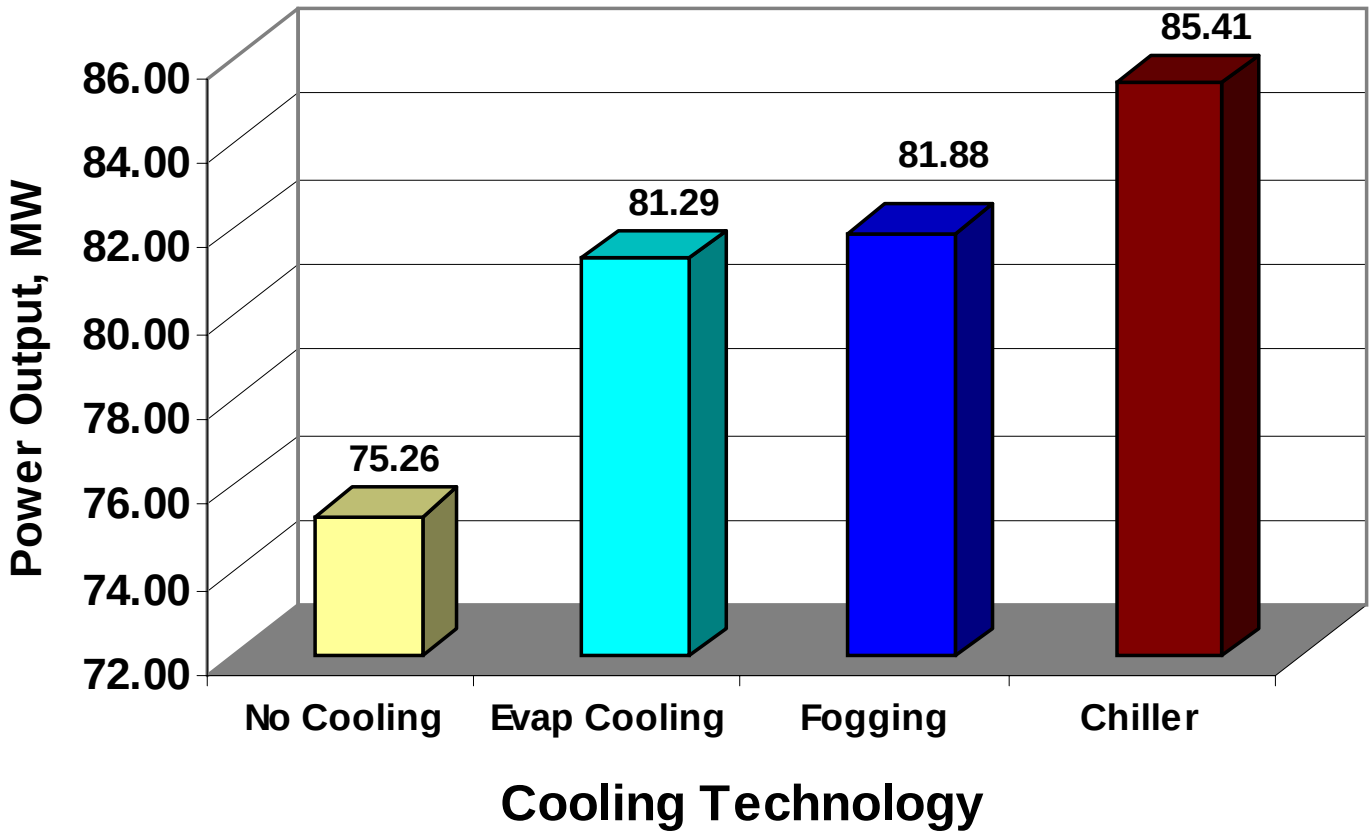


Turbine Inlet Cooling Technologies Options

- Evaporative cooling
- Fogging system
- Electric centrifugal chillers
- Direct-fired double-effect absorption chillers
- Steam-Heated single- or double-effect absorption chillers
- Hot water heated single-effect (HWSE) absorption chillers
- Hybrid systems of some of the compatible options

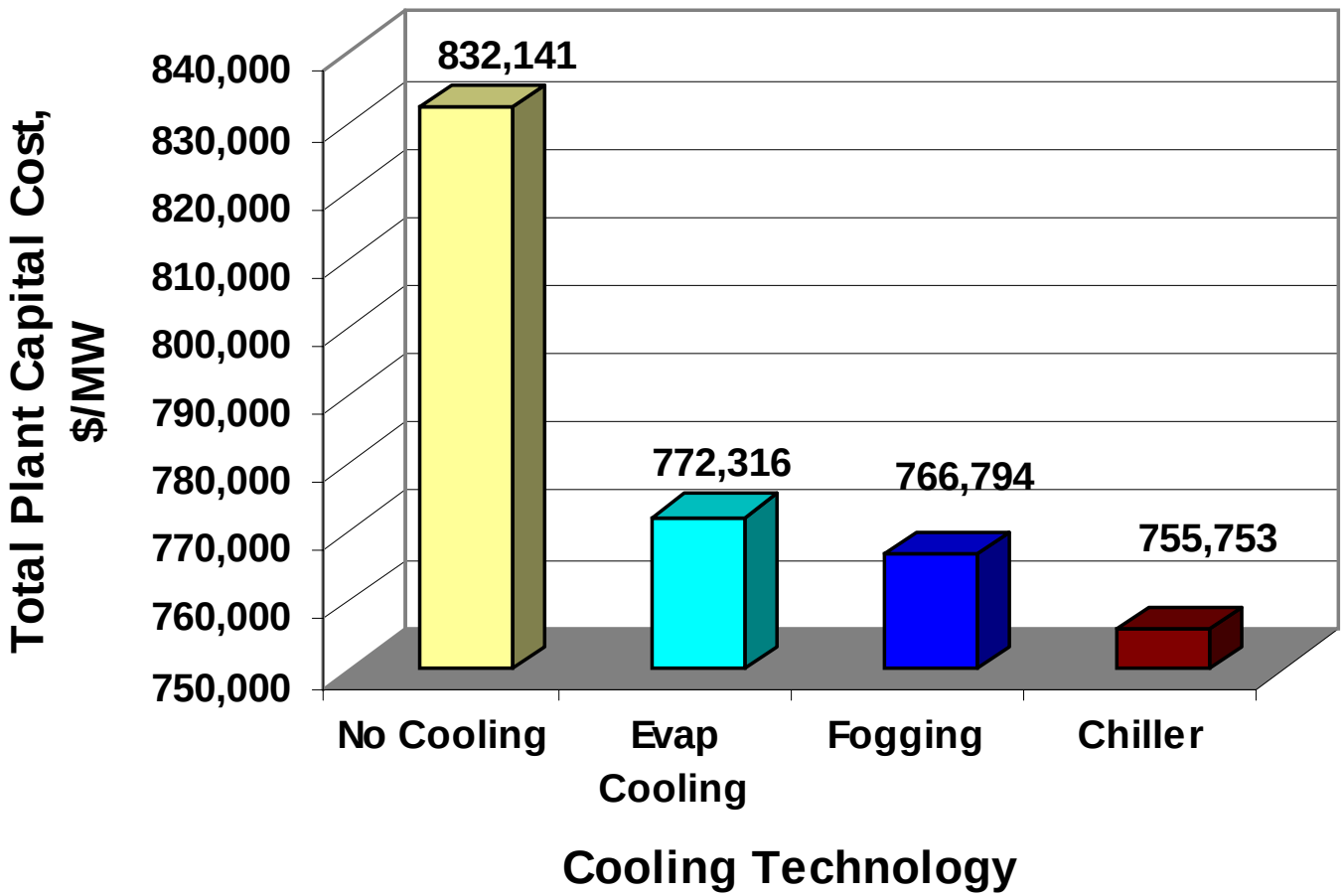
Effect of TIC on Power Output of a 83.5 MW Rated Gas Turbine

Los Angeles (87F DB, 64F WB); Evap (90% Approach); Fogging (98% approach); Electric chiller (Cools to 45°F)



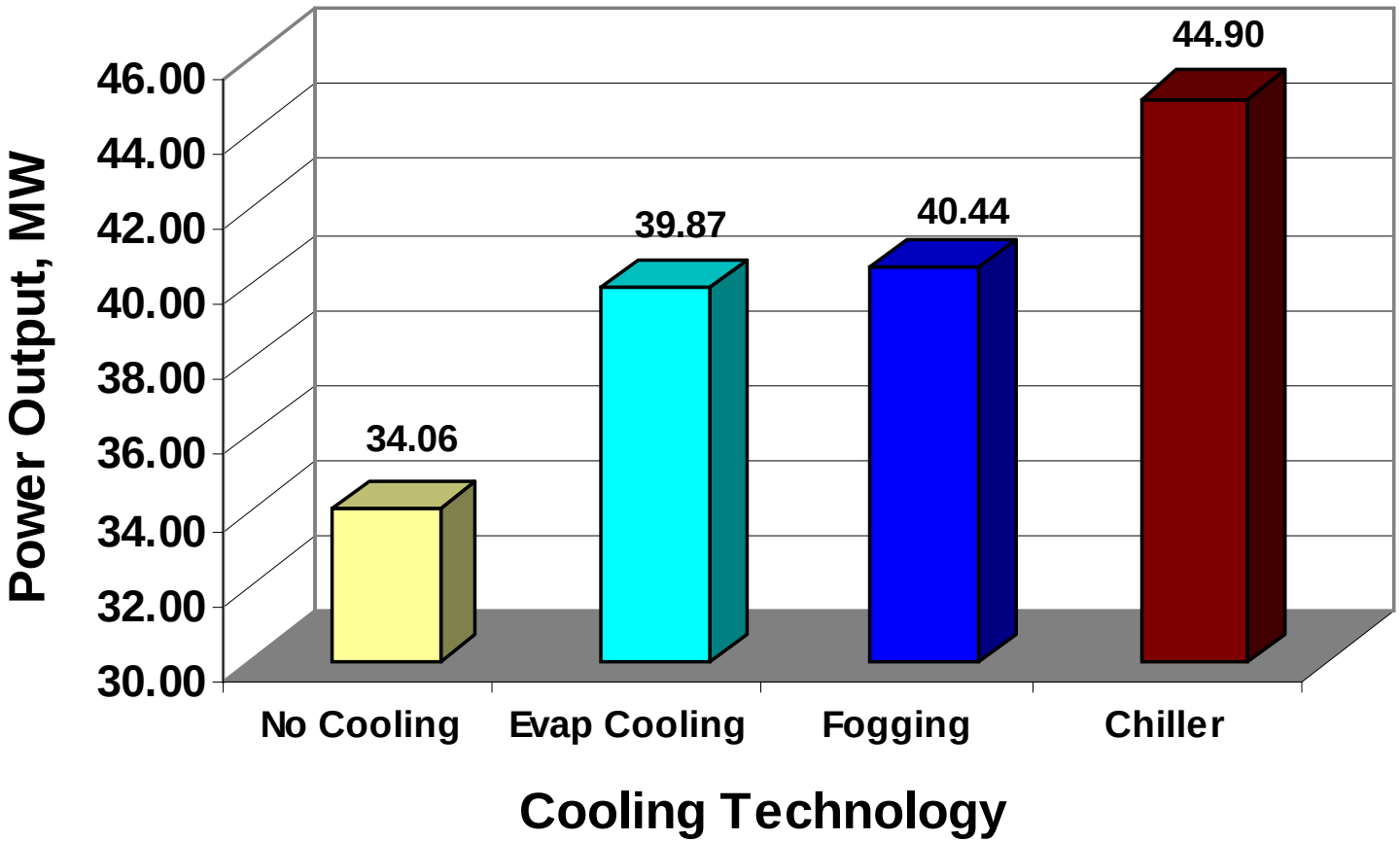
Effect of TIC on Plant Capital Cost for a Cogen Plant with a 83.5 MW Rated Gas Turbine

Los Angeles (87F DB, 64F WB); Evap (90% Approach); Fogging (98% approach); Electric chiller (Cools to 45°F)
Cogen Plant $750,00/MW; Evap & Fogging $1,.900/MW; Chiller $800/RT



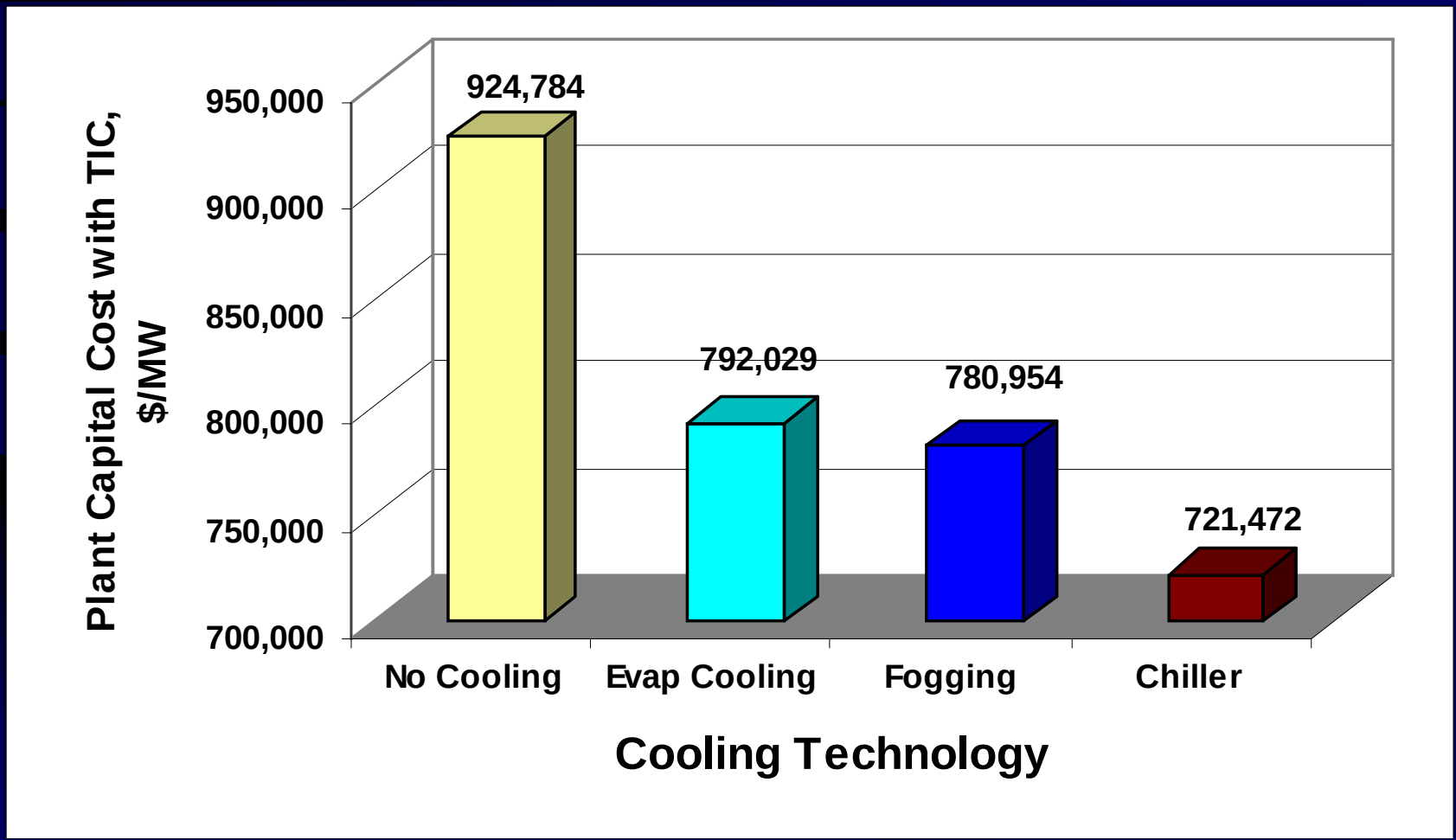
Effect of TIC on Power Output of a 42.0 MW Rated Gas Turbine

Los Angeles (87F DB, 64F WB); Evap (90% Approach); Fogging (98% approach); Electric chiller (Cools to 45°F)



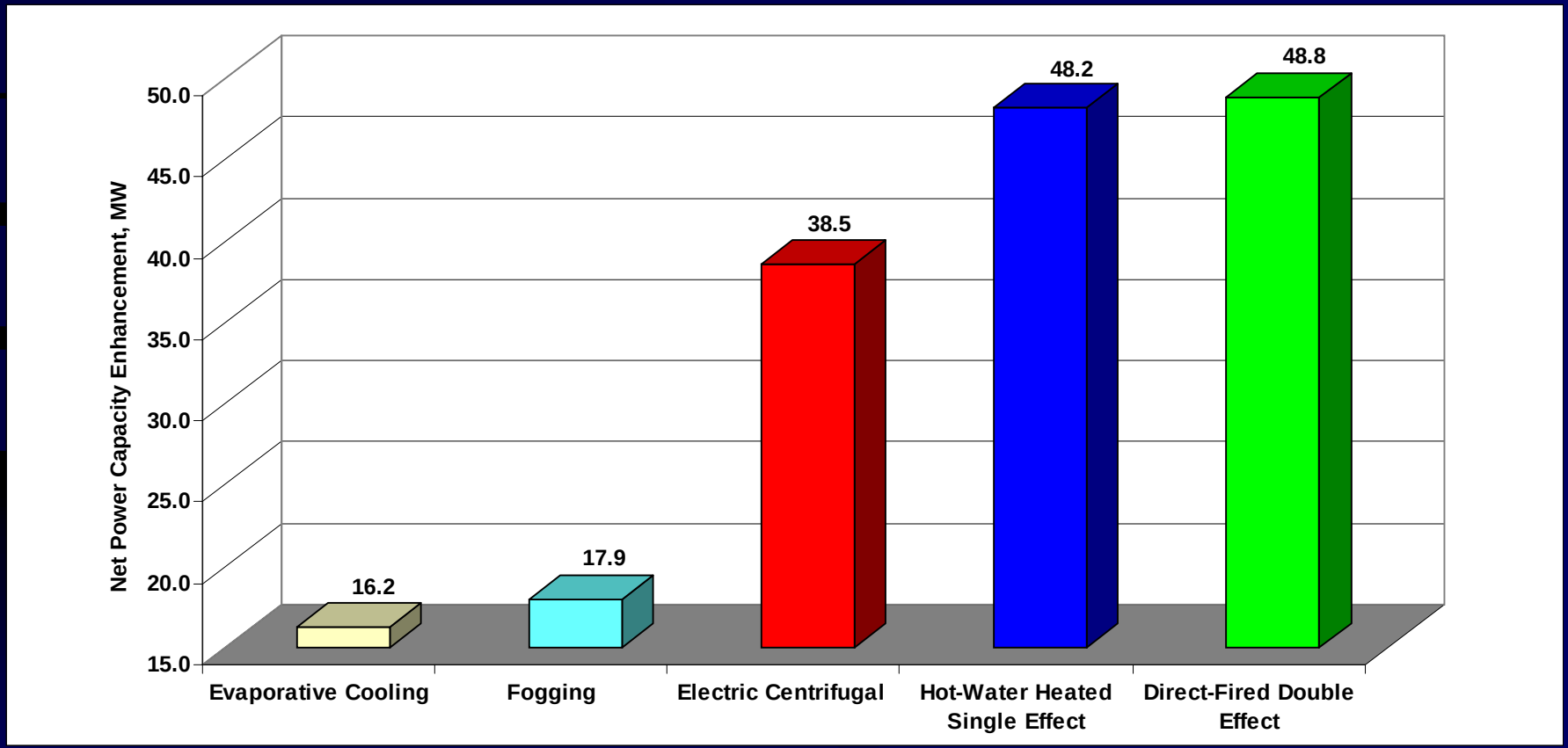
Effect of TIC on Plant Capital Cost for a Cogen Plant with a 42.0 MW Rated Gas Turbine

Los Angeles (87F DB, 64F WB); Evap (90% Approach); Fogging (98% approach); Electric chiller (Cools to 45°F)
Cogen Plant $750,000/MW; Evap & Fogging $1,.900/MW; Chiller $800/RT



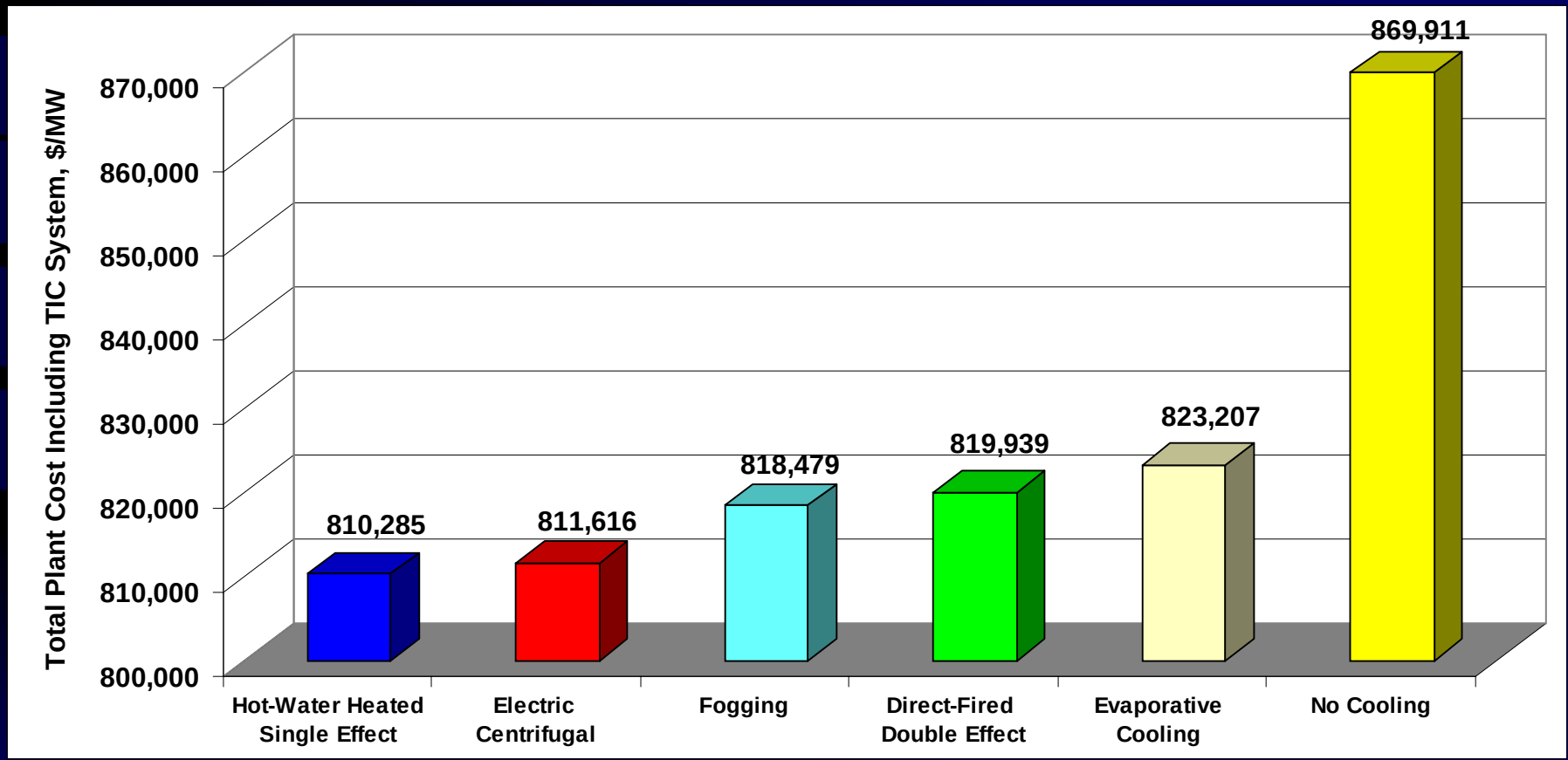
Effect of Chiller Technology on Increase in Net Power Capacity

Ambient DB 95°F (35°C) and WB 80°F (26.6°C); Chillers cool inlet air to 50°F (10°C); 90% and 98% approaches to equilibrium for evap and fogging systems, respectively



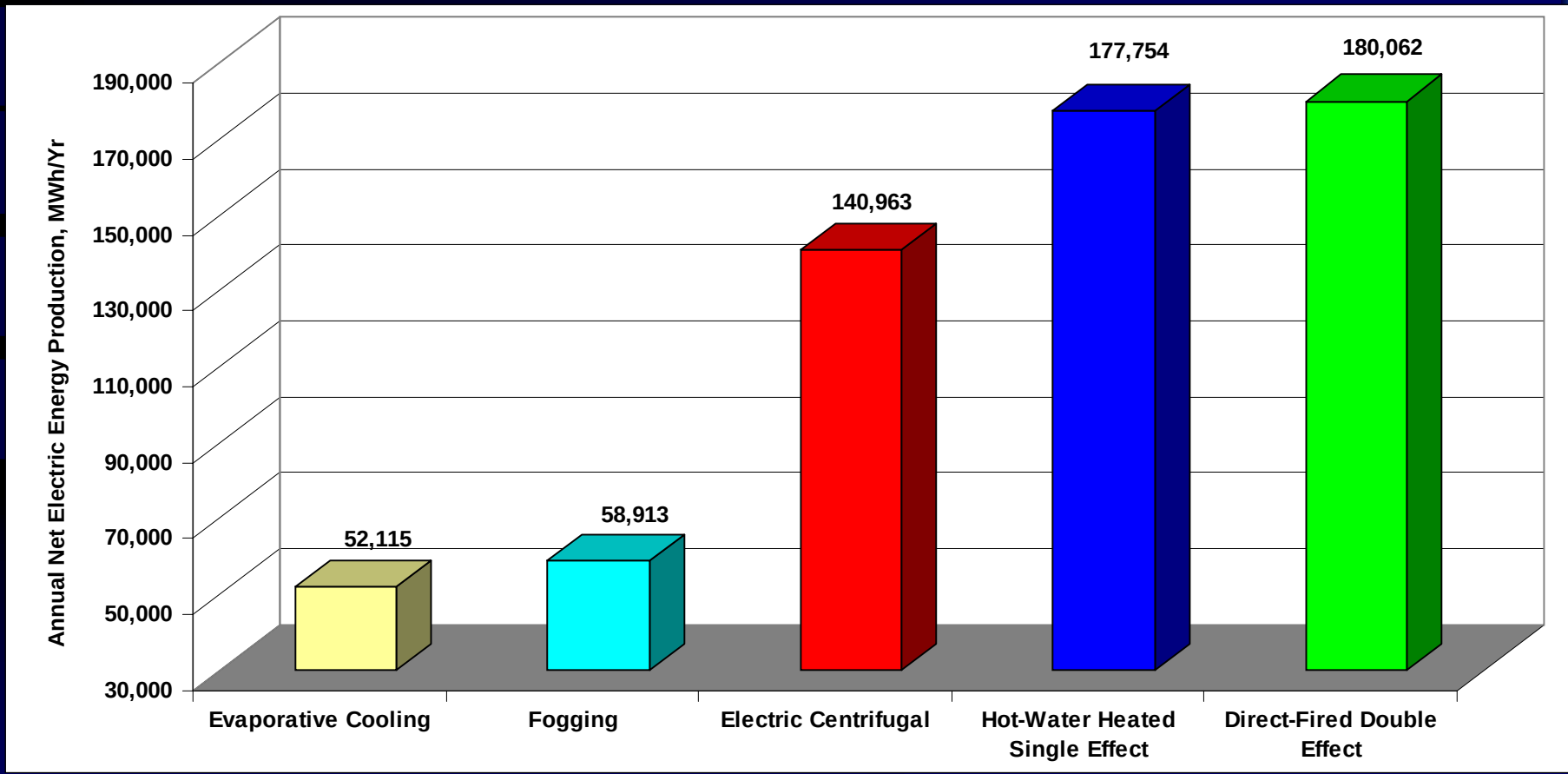
Effect of Chiller Technology on Total Plant Cost Including TIC System

Ambient DB 95°F (35°C) and WB 80°F (26.6°C); Chillers cool inlet air to 50°F (10°C); 90% and 98% approaches to equilibrium for evap and fogging systems, respectively



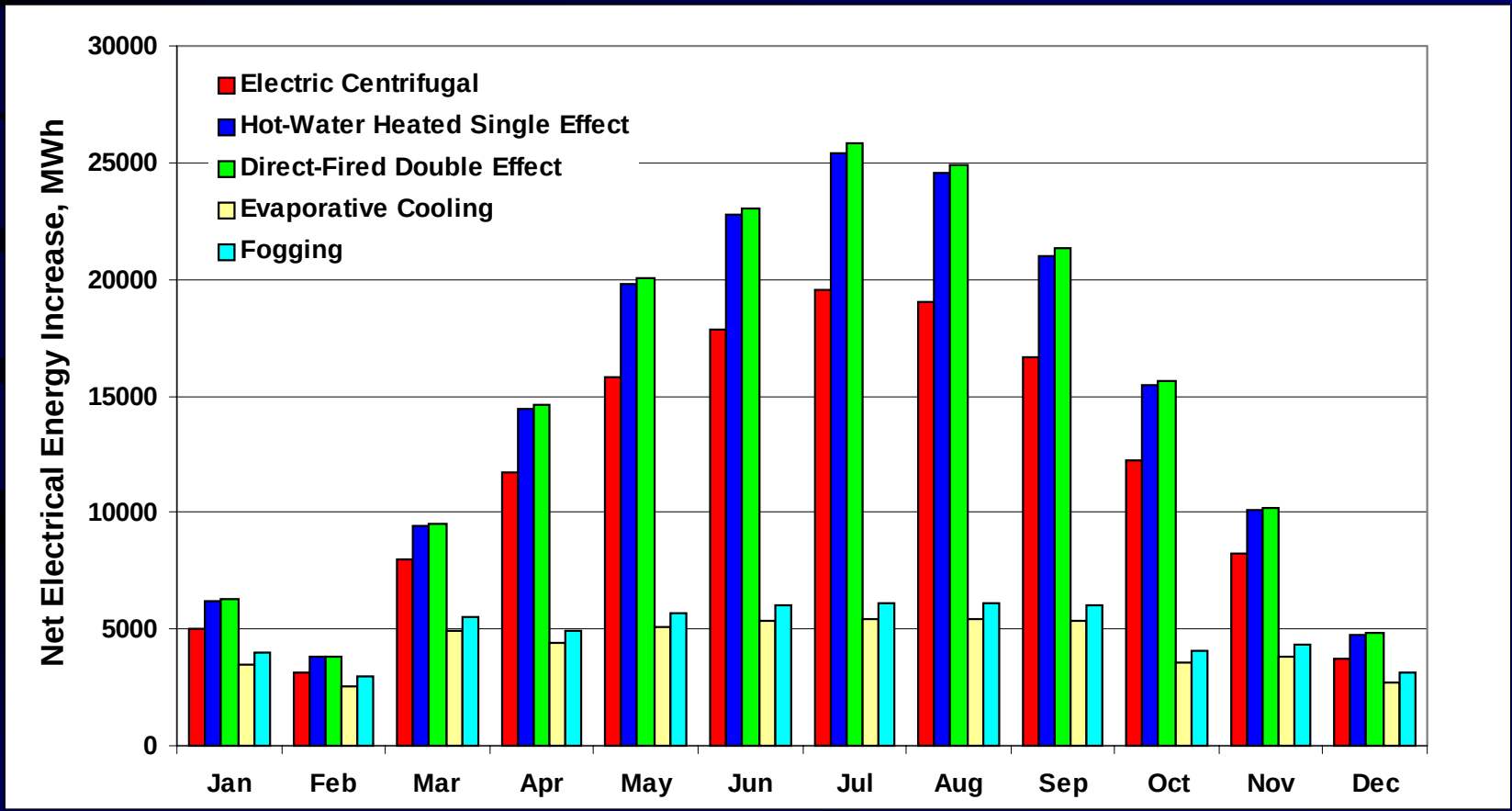
Effect of Cooling Technology on Increase in Annual Net Electric Energy Produced

8760 hour annual operation; Chillers cool inlet air to 50°F (10°C) whenever ambient temperature exceeds 50°F (10°C); 90% and 98% approaches to equilibrium for evap and fogging systems, respectively



Effect of Cooling Technology on Monthly Increase in Net Electric Energy Produced

8760 hour annual operation; Chillers cool inlet air to 50°F (10°C) whenever ambient temperature exceeds 50°F (10°C); 90 % and 98 % approaches to equilibrium for evap and fogging systems, respectively



Factors Affecting the Selection and Economics of TIC Technology

- Combustion turbine characteristics
- Plant location (Local DB and WB temperature profile)
- Electric power demand profile
- Electric energy selling price profile
- Combustion turbine fuel cost profile

TIC system must be optimized for each plant

CTIC is Flexible and Compatible with and Complementary to Many Other Technologies

Applications

- Stand-alone technology
- Combined with other technologies:
  - Cogeneration
  - Thermal Storage
  - District Energy
  - Duct Firing

One Example of TIC Integrated with Cogeneration and Thermal Storage

317 MW (3x105.6 MW) Cogeneration plant in Pasadena, Texas incorporates:

- 8,300 RT hot-water heated absorption chiller
- 1,200 RT electric centrifugal chiller
- 107,000 Ton-hr Thermal Storage capacity. 184,000 Ton-Hrs of Cooling

Turbine Inlet Cooling Association (TICA): A Comprehensive Source of TIC Information

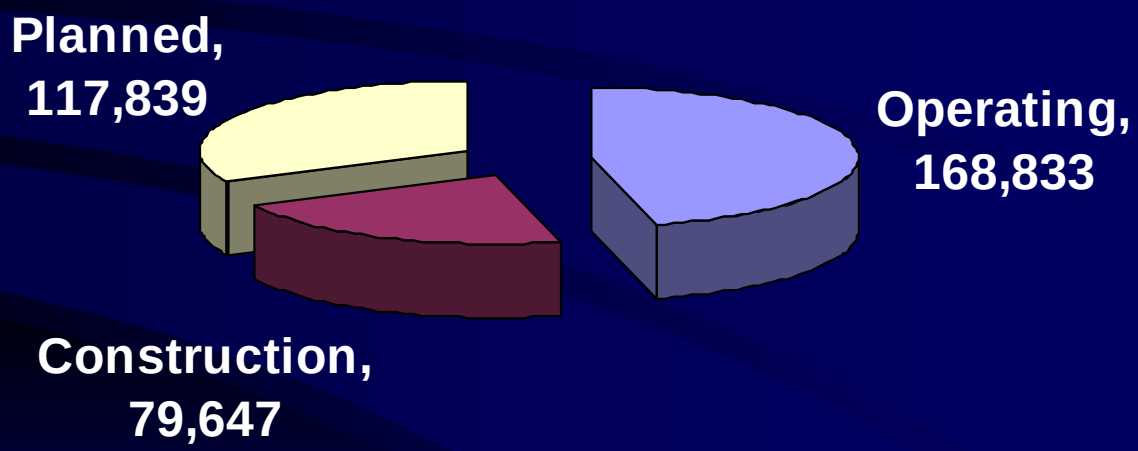
- **TICA promotes development and exchange of knowledge related to TIC**
- **TICA Website www.turbineinletcooling.org**

  is a comprehensive source of information on

  - TIC technology
  - TIC-related published papers
  - TIC system & component vendors and their Websites and information on some specific TIC installations

CT-Based Plants in the U.S.

Total U.S. Gas Turbine Capacity in MW in 2002



Combustion Turbine Inlet Cooling (CTIC) is a Well Established Technology

- CTIC is Commercially used around the world
- Hundreds of plants in the U.S. use CTIC
- Many more power plants could benefit from CTIC

Summary

- TIC could be very attractive for combustion turbine power plants for dealing with current and restructured energy markets
- TIC is being commercially used in many plants across the U.S. and the world
- Significant potential exists for many other plants to benefit from TIC
- TICA Website www.turbineinletcooling.org
  is a comprehensive source of information on TICA