Turbine Inlet Cooling: Good for Plant Owners, Rate Payers and the Environment

Bill Mc Auliffe
Vice Chair, Turbine Inlet Cooling Association

Electricity Committee Meeting,
National Association of Regulatory Utility Commissioners

San Francisco, CA

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Turbine Inlet Cooling Association

- Founded in 2000
- Not-for-profit trade association
- Membership consists of manufacturer's, consultants and power plant owners
- Mission is to educate and demonstrate the economic and environmental benefits of TIC technology to combustion turbine plant owners, policy makers, and government agencies.

Overview

- Combustion turbine (CT) fundamental flaws
- Turbine Inlet Cooling (TIC) overcomes the effect of the flaws
- Economic and environmental benefits
- Technology options available for TIC
- Suggested regulatory changes
  for removing barriers to TIC implementation

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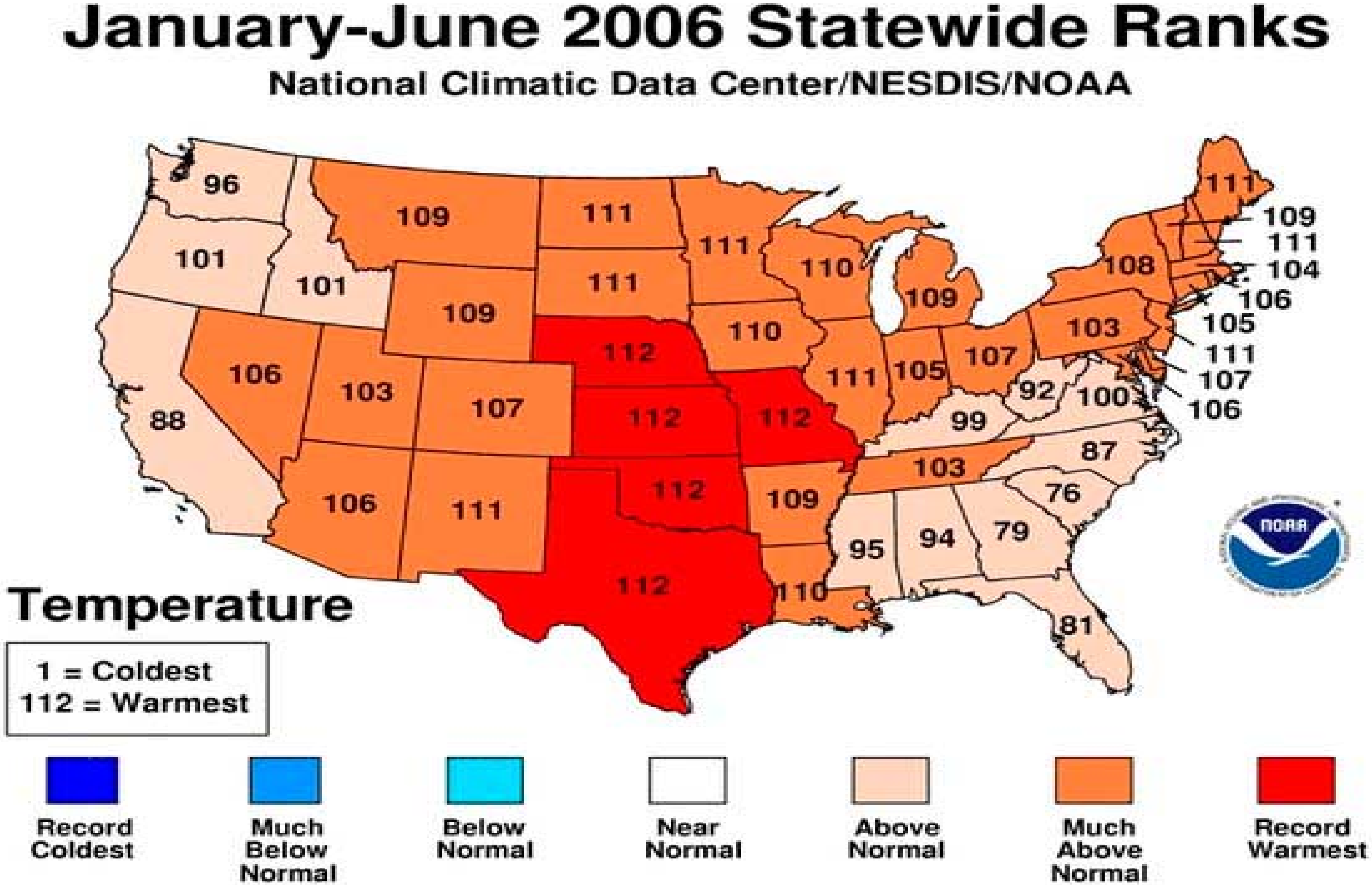
January-June 2006 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA
96
109
111
111
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101
101
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111
104
106
105
111
107
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111
105
107
92
100
99
88
87
103
112
109
76
106
111
95
94
79
112
110
81
Temperature
1 = Coldest
112 = Warmest
Record Coldest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warmest

Combustion Turbine Power Plants Fundamental Flaws

- **During hot weather, just when power demand peaks,**
  1. Power output decreases significantly
     - *Up to 35% below rated capacity*
     - *Depends on the CT characteristics*
  2. Fuel consumption (heat rate) and emissions increase per kWh

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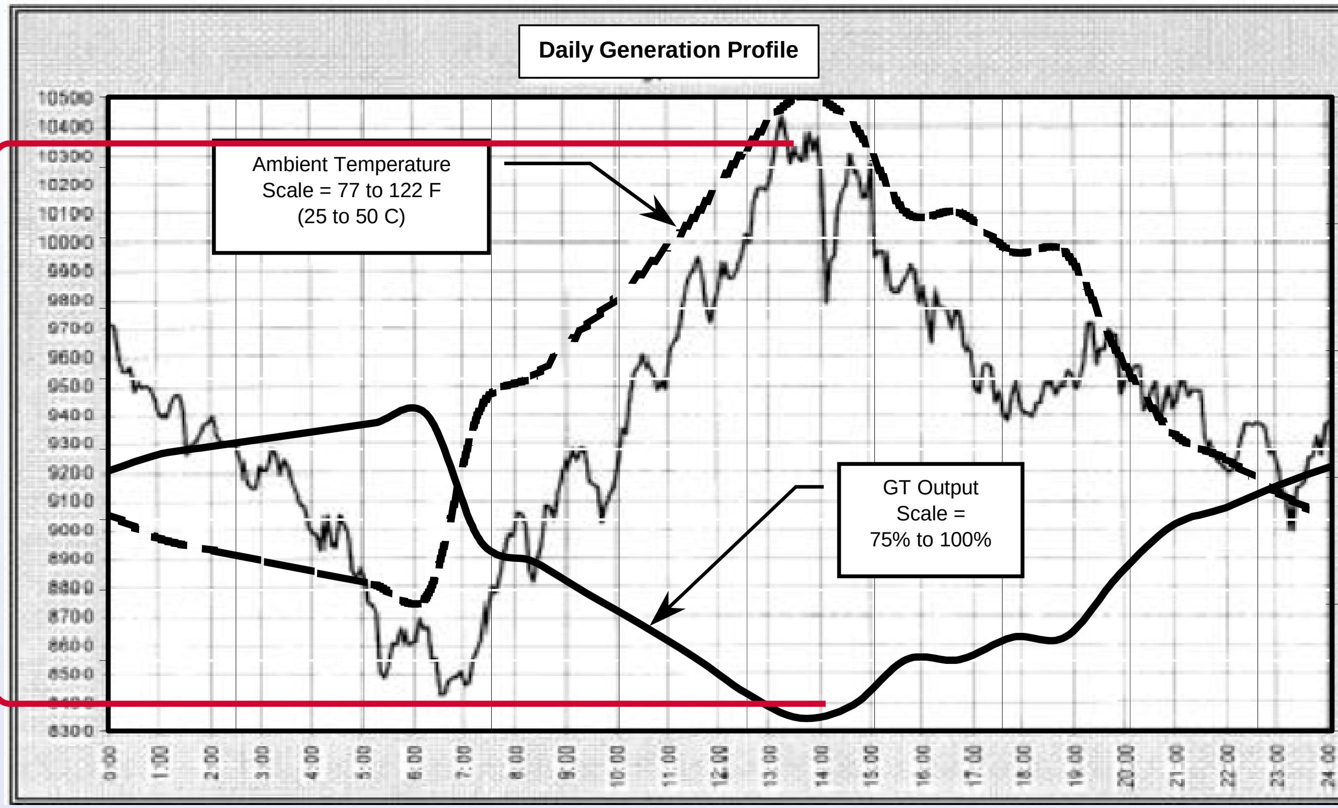
Combustion Turbine Power Plants Fundamental Flaw #1

Greatest generation capacity loss coincides with peak demand



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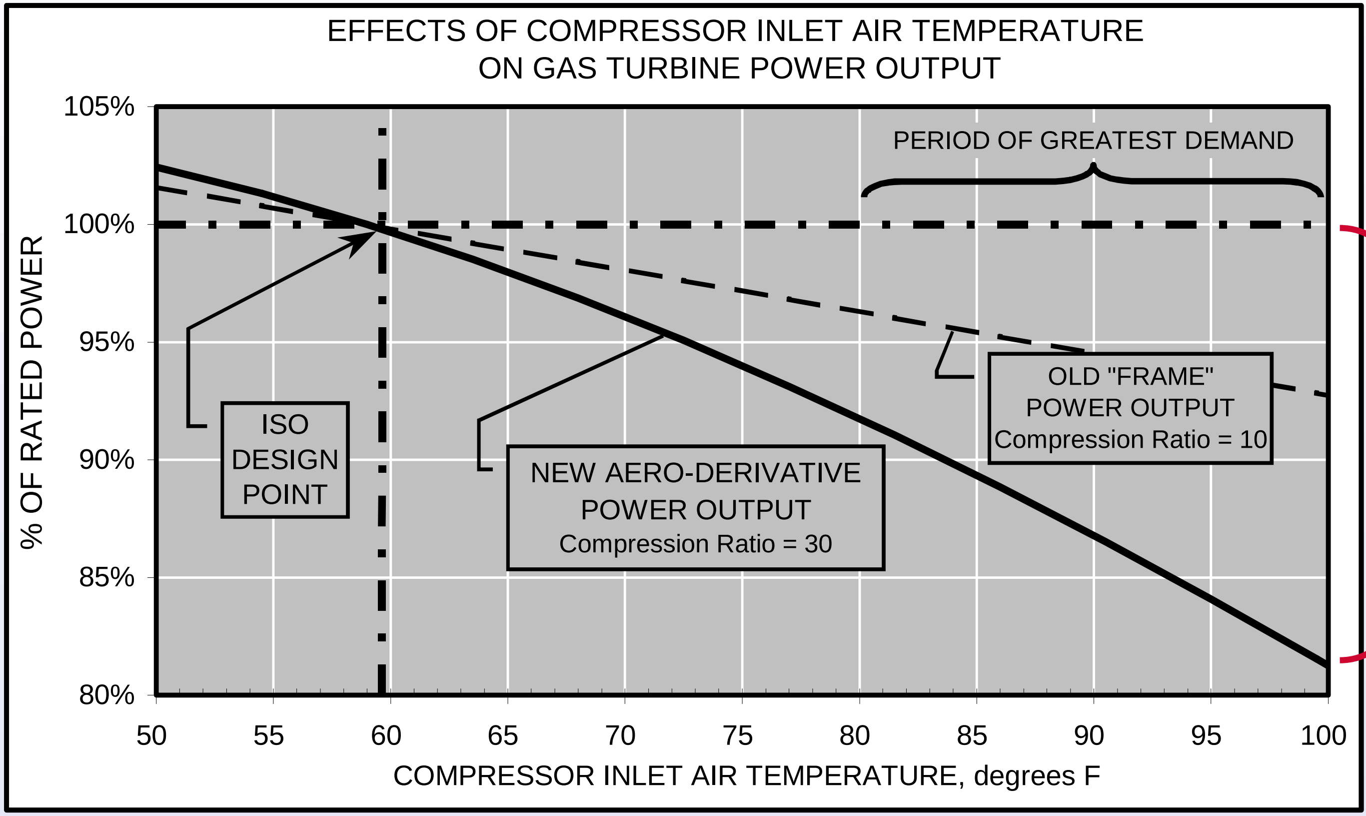
Combustion Turbine Power Plants Fundamental Flaw # 1



Up to 19% capacity loss at peak demand for this CT

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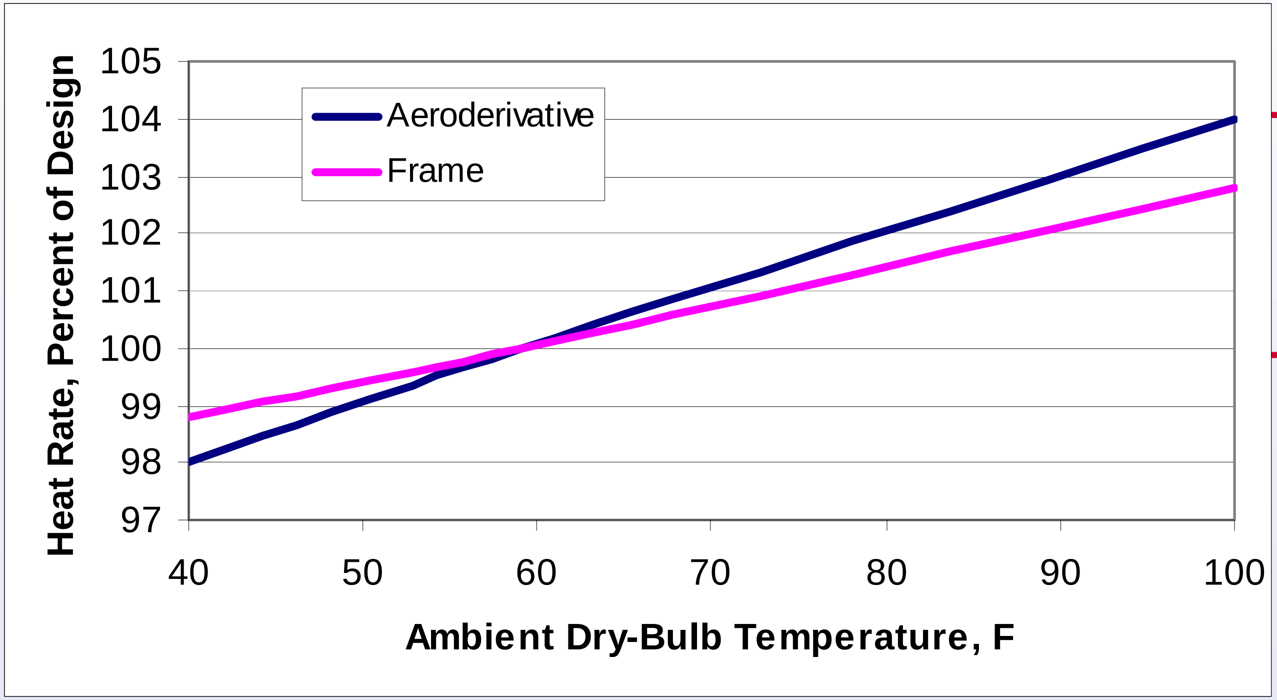
Combustion Turbine Power Plants Fundamental Flaw # 2



Efficiency lost at peak demand

Note: Heat rate is proportional to fuel consumption per kWh

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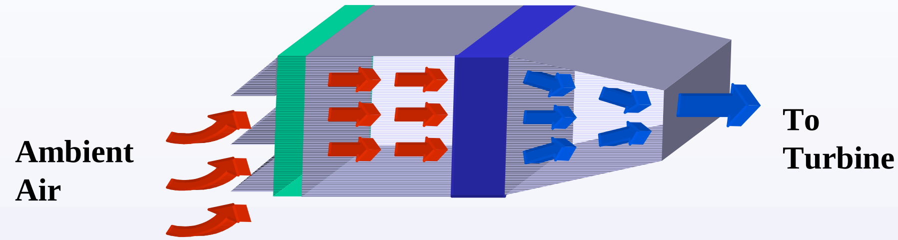
Turbine Inlet Cooling Overcomes the Effect of the CT Flaws



- **TIC is simple**
  - Cool the ambient air before it enters the turbine
  - Just as we cool the air entering buildings
- **TIC technologies are proven**
  - Hundreds of plants already benefit from TIC
  - TICA web site database of 100+ plants worldwide

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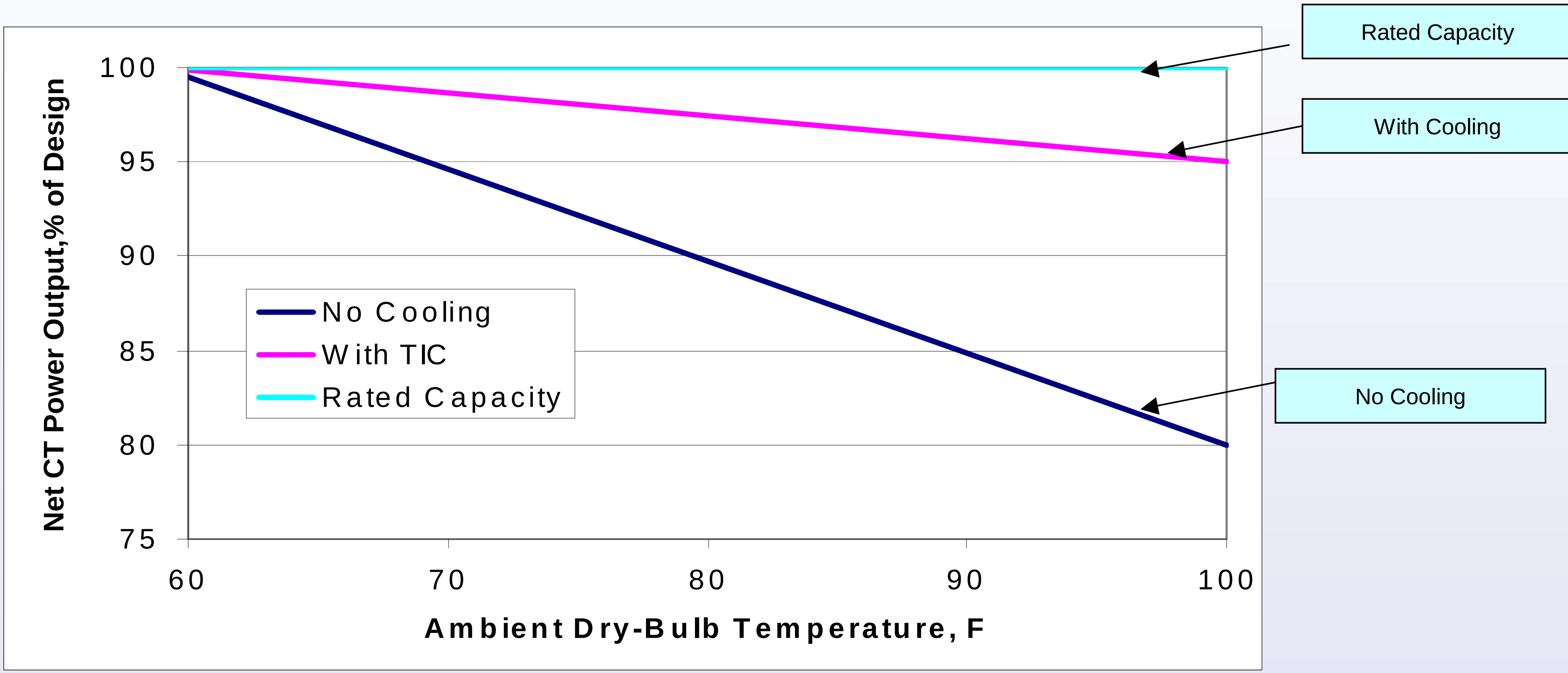
Turbine Inlet Cooling Overcomes the Effect of the CT Flaws



Turbine Inlet Cooling Technologies

- Evaporative cooling
- Fogging
- Air cooled and water cooled chillers
- Absorption chillers
- Thermal storage with chillers
- Other technology combinations

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Turbine Inlet Cooling Economic Benefits

- **Captures "lost / hidden" capacity during hot weather**
  - when most needed
  - when most valuable
- **Minimizes the need to build new power plants to meet peak demand**

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Turbine Inlet Cooling Economic Benefits

- **Enhances CT asset value**
  - Reduces capital cost per MW of capacity
  - Improves fuel efficiency
    (lower fuel use and cost per kWh)
- **Reduces cost for ratepayers by allowing lower capacity payments for power producers**

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Turbine Inlet Cooling Environmental Benefits

- **Offsets operation of inefficient and higher-emission power plants**
- **Improves operation of efficient and cleaner combustion turbine plants**
  - Reduces pollutant emissions (SOx, NOx, particulates)
  - Reduces global warming gas emissions (CO_2)
  - See quantitative details in Exhibit 1
- **Minimizes, delays, or eliminates new plants**

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Turbine Inlet Cooling Environmental Benefits

Emissions* for 100 MW for 400 hours

	Combined-Cycle CT	Simple-Cycle CT	Steam Turbine
Fuel	Natural Gas	Natural Gas	No. 6 Fuel Oil
CO_2 Emissions, Tons	16275	24993	44730
NOx Emissions, Tons	1.60	7.33	78.00
SOx Emissions, Tons	0	0	265

* Source: Ray Pasteris, Strategic Energy Services, Inc

➔ **TIC Implementation Priority Order For Minimizing Emissions**

- Combined-Cycle CT Systems

- Simple-Cycle Systems

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Suggested Changes To Regulatory Structure

- **Realize full potential of existing CT plants**
  - Use TIC before allowing new plants to be built
- **Exempt TIC from environmental re-permitting**
  - Impact of TIC is similar to ambient temperature naturally going down
- **Calculate capacity payments for plant owners on the basis of systems incorporating TIC**
  - Consistent with the PJM affidavit made to the FERC

    (Summary shown in Exhibit 2)

Contact Information

Bill Mc Auliffe
Vice Chair – TICA
bill.mcauliffe@york.com
281.635.2812

Dennis Halsey
President - TICA
DHalsey@fessystems.com
630.983.0883

Exhibit 1

Exhibit 1
TICA Presentation at the NARUC Meeting July 31, 2006

	TIC Candidates		Existing Older Plants
Unit Type	**Combined-Cycle CT**	**Simple-Cycle CT**	**Boiler + Steam Turbine**
Prime Mover	Frame CT- STG	Frame CT	Condensing STG
Fuel	Gas	Gas	No. 6 Oil
Fuel Sulfur (% Wt.)	0	0	0.01
Plant Age (Yrs)	< 5	< 5	> 30
Heat Rate (BTU/kWh)	7,000	10,750	13,000
NOx Control	DLN-SCR	DLN	LNB w/ FGR
NOx Target (PPM)	3	9	NA
NOx (Lbs/MMBTU)	0.0114	0.0341	0.3
SO2 (Lbs/MMBTU)	0	0	1.02
Incremental Capacity (MW)	100	100	100
Hours of Operation	400	400	400
Fuel (MMBTU)	280000	430000	520000
CO2 Emissions, Tons	16275	24993	44730
NOx Emissions, Tons	1.596	7.3315	78
SOx Emissions, Tons	0	0	265.2

LNB = Low Nox Burners
FGR = Flue Gas Recirculation
DLN = Dry Low NOx
SCR = Selective Catalytic NOx Reduction

Source: Ray Pasteris - Strategic Energy Services, Inc. 215-736-8170

Exhibit 2

A Summary of the affidavit (incorporating turbine inlet cooling) made to the Federal Energy Regulatory Commission on behalf of the PJM ISO

Exhibit 2

TICA Presentation Made to the Electricity Committee of NARUC on July 31, 2006

Cost of New Entry Combustion Turbine Power Plant Revenue Requirements
Summary of an independent study conducted for PJM Interconnection, LLC

A team of Strategic Energy Services, Inc. and The Wood Group completed a study in August 2005 for PJM Interconnection, LLC (PJM). The study determined the Cost Of a New Entry (CONE) generator by technology and the resulting fixed revenue requirements. The cost was expressed in $/MW-year or $/MW-day for PJM's three regions.

A 20-year after tax discounted cash flow economic model was created to determine the revenue required for a CONE CT project to earn the target internal rate of return for the investor/owner. The costs included capital recovery and annual fixed operation and maintenance expenses.

The study evaluates CT systems with and without Turbine Inlet Cooling (TIC) at ambient temperatures of 92°F dry-bulb and 78°F wet-bulb. The following table summarizes the capital costs (Investments) for two GE 7241/7FA combustion turbines systems, with and without TIC.

	Without TIC	**With TIC**
Net plant output, MW	297.3	336.1
Plant proper capital cost, $	116,248,000	124,656,000
Investment per kW, $/kW	391.00	370.90
Incremental capacity provided by TIC, MW	NA	38.8
Incremental investment for TIC, $	NA	8,400,000
Incremental investment for the incremental power provided by TIC, $/kW	NA	216.50

TIC increases the total net plant output of the system by 38.8 MW and decreases the capital cost by $20/kW ($371 vs. $391). The additional first cost for the incremental power provided by TIC is $216/kW.

Because the incremental and blended investments per kW are lower for the CT with TIC, the evaluation team recommends that PJM use TIC for determining the revenue requirements for the CONE generators. PJM agrees with that recommendation and included the details of this study in the affidavit made on its behalf to the Federal Regulatory Commission (FERC). The information for this summary has been extracted from pp 89 – 94 of the affidavit. Details of the affidavit are available at the PJM website:
http://pjm.com/documents/ferc/documents/2005/20050831-er05-___-part-5.pdf