Update on EEA Activities for ORNL/DOE DG/CHP Program

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Energy and Environmental Analysis, Inc.
www.eea-inc.com

Overview of Today

- CHP Reliability Database
- CHP Facilities Database
- Regulatory Database
- CHP Emissions Calculator

EEA Tasks for DOE/ORNL

- Enhancement to Distributed Generation Operational Reliability Database/Large CHP Market Analysis
- CHP Applications and DG Analytical Support
- Analysis of Environmental Regulatory Barriers and Incentives for CHP
- Analysis of Industrial and Commercial CHP Markets
- State Regulatory Database

DG/CHP Operational Reliability Database
(4000021456)

- Completed DG/CHP OR DB Version 2.0 1Q 2004
- New data collected and integrated
  - 121 units represent the most comprehensive data on DG OR performance
- EEA-developed methodology is basis of NYSERDA-funded project on a web-based tool to allow for secure entry and assessment of operational reliability performance data
  - Included in NYSERDA CHP Data Integrator as well

DG Operational Reliability and Availability Database

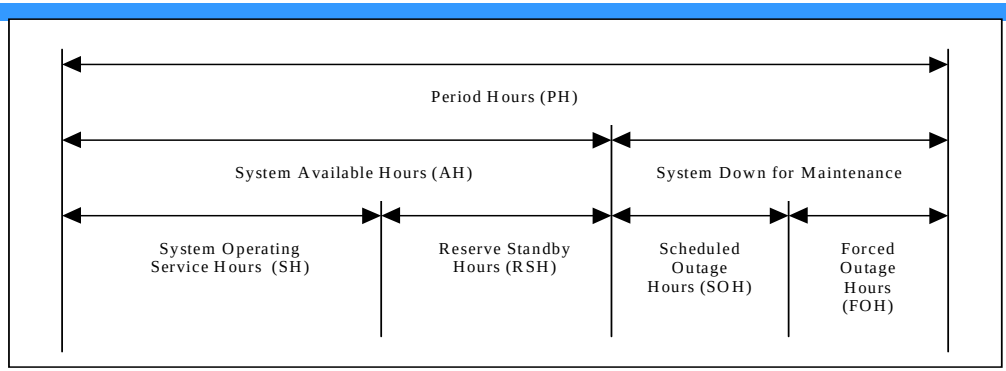
- Data needed to establish baseline operating and reliability data for industrial and commercial DG and CHP systems
  - DG/CHP system reliability and availability is a critical element in DG market development
- Data from maintenance logs, operation records, and other available sources
  - Exhaustive collection of data from a sample of operating facilities
  - Methodology is based on actual customer data
    - ☆ Dependent on customer participation
    - ☆ Customer-based process creates better understanding of DG operations
    - ☆ Leverages substantial prior work by others on evaluating onsite power system reliability
- Identify and classify DG/CHP system failures and causes of forced outages

Operational Reliability and Availability Database Benefits

Database of operational reliability data for DG systems:

- Current DG/CHP facility managers better understand reliability and availability performance
  - Their particular units
  - Determine how facilities compare with other DG resources
  - Availability and downtime impacts
- Potential DG/CHP users make more informed purchase decisions
  - System reliability impacts
  - Availability and downtime impacts
- Policy makers quantify potential benefits of customer-sited DG/CHP
  - Standby and back power components of tariffs
  - System reliability impacts

Operational Reliability and Availability Indices



OR Measure	Formula
Period of Demand (POD, hours): Measures the time the unit was planned to operate.	POD = PH-RSH-SOH
Availability Factor (AF, %): Measures, on a percent basis, the unit's "could run" capability. Impacted by planned and unplanned maintenance.	AF = (PH-SOH-FOH) * 100 / PH
Running Availability (RR, %): Measures, on a percent basis, probability of avoidance of forced outages. Accounts for planned, unplanned, and administrative outages.	RR = PH-FOH-SOH-AOH *100 / PH-SOH-AOH
Forced Outage Rate (FOR, %): Measures portion of time due to unplanned factors	FOR = FOH * 100 / (SH+FOH)
Scheduled Outage Factor (SOF, %): Measures percent of time set aside for planned maintenance	SOF = SOH * 100 / PH
Service Factor (SF, %): Percent of total period hours the unit is on-line. Varies due to site related or economic factors	SF = SH * 100 / PH
Mean Time Between Force Outages (MTBFO, hours): Measure the nominal time between unscheduled forced outages	MTBFO = SH / # Forced Outages
Mean Down Time (MDT, hours): Measures the nominal duration the unit is down during maintenance events	MDT = SOH+FOH / # Forced Outages + # Planned Outages

Summary of Results

- Specific units were observed to exhibit both very good to poor OR performance
- In almost all technology groups, subsystems other than the prime movers themselves contributed more significantly to the occurrence of forced outage events
  - OR performance of established commercial technologies (i.e., reciprocating engines and gas turbines) was significantly better than the sample of emerging technologies (fuel cells) in the sample
  - The OR performance of emerging technologies and early commercial products need to be compared separately
    - ☆ Established products have the benefit of millions of hours of operation from which to develop operations and maintenance best practices. Their observed performance in this project and prior work bears this out.
    - ☆ As time passes and more experience is gained from the operation of emerging technologies, it is likely their demonstrated OR performance will improve to the level of the other technologies.
    - ☆ Fuel Cell availability, forced outage rate and mean down time was greatly affected by downtime associated with unusually long delays (e.g., maintenance personnel response, availability of replacement parts, site operations) and not related to typical operation.
    - ☆ In those specific cases the availability calculated can become more a measure of the service system than the inherent disposition of the equipment to perform.
- There was no identification of any systemic problems. Most failures within technology groups appear to be random occurrences expected of any complex power system

Summary of Results

Reciprocating Engine Systems

Reciprocating Engines	<100kW			100-800 kW			800-3000 kW		
Number Sampled	14			8			18		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Availability (%)	96.27	97.93	99.00	84.55	95.99	99.93	91.14	98.22	100.00
Forced Outage Rate (%)	0.86	1.76	3.07	0.00	1.98	5.05	0.00	0.85	6.63
Scheduled Outage Factor (%)	0.26	0.73	1.33	0.07	2.47	14.22	0.00	1.12	3.42
Service Factor (%)	68.20	75.11	79.60	2.06	51.76	95.43	1.50	40.59	91.39
Mean Time Between Forced Outages (hrs)	505.96	784.75	1376.60	361.18	1352.26	4058.71	263.00	3582.77	14755.30
Mean Down Time (hrs)	7.29	13.71	24.21	12.50	50.66	173.05	0.00	27.06	91.91

Summary of Results

Gas Turbine Systems

Gas Turbines	0.5-3 MW			3-20 MW			20-100 MW		
Number Sampled	11			21			9		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Availability (%)	88.88	97.13	100.00	88.56	94.97	99.60	86.33	93.53	99.45
Forced Outage Rate (%)	0.00	2.89	18.84	0.00	2.88	9.07	0.00	1.37	6.63
Scheduled Outage Factor (%)	0.00	0.99	4.57	0.00	2.39	11.44	0.00	5.14	13.50
Service Factor (%)	5.33	57.93	97.27	6.26	82.24	99.01	70.27	88.74	99.45
Mean Time Between Forced Outages (hrs)	765.62	2219.72	4318.00	216.77	1956.46	15298.00	536.00	3604.62	17424.00
Mean Down Time (hrs)	0.17	65.38	325.09	2.77	68.63	501.75	21.29	75.30	288.50

Summary of Results

Fuel Cell and Steam Turbine Systems

Other Technologies	Fuel Cells <200kW			Steam Turbines <25MW		
Number Sampled		15			25	
	Min.	Avg.	Max.	Min.	Avg.	Max.
Availability (%)	42.31	76.84	95.04	72.37	92.02	99.82
Forced Outage Rate (%)	4.31	22.94	57.51	0.00	2.34	16.41
Scheduled Outage Factor (%)	0.48	0.92	1.23	0.00	6.01	27.63
Service Factor (%)	42.27	74.01	92.21	3.37	81.12	99.65
Mean Time Between Forced Outages (hrs)	1416.71	2004.47	2696.33	120.18	5317.73	29585.00
Mean Down Time (hrs)	66.92	369.24	1686.83	5.51	292.06	4848.00

Summary of Results

Entire Sample

	Technology Group	n	Availability (%) Avg.	Outage Rate (%)	Outage Factor (%)	Factor (%) Avg.	Between Forced	Mean Down Time (hrs)
RE	1	14	97.93	1.76	0.73	75.11	784.75	13.71
RE	2	8	95.99	1.98	2.47	51.76	1,352.26	50.66
RE	3	18	98.22	0.85	1.12	40.59	3,582.77	27.06
FC	4	15	76.84	22.94	0.92	74.01	2,004.47	369.24
GT	5	11	97.13	2.89	0.99	57.93	2,219.72	65.38
GT	6	21	94.97	2.88	2.39	82.24	1,956.46	68.63
GT	7	9	93.53	1.37	5.14	88.74	3,604.62	75.30
ST	9	25	92.02	2.34	6.01	81.12	5,317.73	292.06
	Entire Sample	121	93.09	4.65	2.66	70.23	2,869.83	138.53

Summary of Results

Duty Cycle

Duty Cycle	Service Factor Range	N	Availability (%) Avg.	Forced Outage Rate (%) Avg.	Scheduled Outage Factor (%) Avg.	Service Factor (%) Avg.	Mean Time Between Forced Outages (hrs)	Mean Down Time (hrs)
Peak	1-10%	14	99.42	0.02	0.58	2.60	456.80	22.21
Cycling	10-70%	26	88.76	10.15	2.16	54.03	2,339.48	383.19
Baseload	>70%	81	93.39	3.69	3.18	87.11	3,457.13	80.10
Entire Sample	0-100%	121	92.62	6.48	1.59	36.86	1,659.54	250.93

Issues Identified

- Extremely labor intensive data collection
  - Log books, outage summary reports, maintenance/contractor service reports
  - Wide variation in record keeping
- Database just addresses a 2-year window in time
- Wide variation between conventional and emerging technologies/demonstrations identify the clear need to differentiate between the two types

CHP Facility Database

Objective: Collect basic information on existing CHP facilities and track new installations over time:

- Develop comprehensive database of existing CHP facilities with basic site and CHP system information
- Measure progress toward CHP Challenge goal
- Gauge the impact of CHP on specific regions and applications

CHP Facility Database

Current Effort: Build upon previous work to update existing CHP profiles for 2003 and beyond:

- Complete merging and verification of EEA/Hagler Bailly data with EIA Non-utility Database; update with latest EIA data on an ongoing basis
- Add additional sites from FEMP data, IDEA data, EEA reliability database and other public sources
- Expand coverage of sites < 1 MW through equipment supplier and packager data
- Verify and expand state data through Regional Application Centers

CHP Facility Database – Data Fields

Basic Data (have for 95%+ of facilities)

- Organization name
- Facility name
- Location – city, state, zip code
- SIC code (two and four digit)
- Prime mover (type and number)
- Fuel (primary and secondary)
- Capacity, kW
- Year of initial operation
- Status (operating, standby, retired)

CHP Facility Database – Data Fields

Expanded Data

- Servicing utility
- Sales to grid (Y/N)
- Contact information
- MWhs generated (EIA data)
- Equipment manufacturer and model
- Thermal use

CHP Facility Database – EIA Data

EIA CHP Comparison

	EIA 2002 MW	Prelim EIA 2003 MW
Operating	77,605.6	61,010.6
Standby	4,490.5	5,154.7
Retired	713.4	334.3
Out of Service	1,370.9	773.9
Wind/Hydro	229.6	493.5
Total	84,410.0	67,766.4

*Using EIA fields COGEN, FERCCOGEN, and FERCQUAL

48 CHP Sites new to EIA 2003, not in 2002

11 Hydro Sites (27.3 MW)
3 Wind Sites (435.4 MW)
4 Not CHP (1998.4 MW)
30 In EIA 2001 as CHP (1776 MW)

CHP Facility Database – EIA Data

EIA – EEA Facility Database Comparison:

- EEA data includes 1230 EIA sites (72,528 MW)
- 1,043 are listed as CHP in EIA 2002 (62,486 MW)
- 36 are listed as CHP in EIA 2001, but not in EIA 2002 (1,944 MW)
- 151 are in EIA 2001/2002 but not listed as CHP (8,096 MW)

CHP Facility Database – 2004

- 2004 capacity: 2900 sites; 79,879 MW
- Average size: 27.5 MW
- Median size: 2.0 MW

CHP Facility Database – CHP Growth

Total

	1995		1999		2000		2003		2004	
	Sites	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**
Commercial	1061	5,394.2	1350	7,200.6	1385	7,817.6	1531	8,987.7	1540	9,024.1
Industrial	981	44,966.4	1070	51,437.7	1114	54,005.8	1185	64,543.2	1189	65,611.7
Other	147	4,464.5	162	4,840.2	165	4,844.0	171	5,243.4	171	5,243.4
Total	**2,189**	**54,825.1**	**2,582**	**63,478.5**	**2,664**	**66,667.4**	**2887**	**78,774.3**	**2,900**	**79,879.2**

Commercial

	1995		1999		2000		2003		2004	
	Sites	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**
SIC 4961: District Energy	21	581.2	24	736.1	25	741.1	32	1,479.7	32	1,479.7
SIC 6513: Apartments	85	95.2	98	96.3	101	96.5	104	97.0	104	97.0
SIC 7011: Hotels	77	30.1	82	31.9	82	31.9	102	41.6	102	41.6
SIC 8051: Nursing Homes	54	8.8	79	11.3	82	11.5	96	24.3	96	24.3
SIC 8060: Hospital/Healthcare	123	479.5	143	562.9	144	562.9	154	582.5	154	582.5
SIC 8211: Schools	103	16.7	145	39.3	157	42.2	160	42.8	160	42.8
SIC 8220: Colleges/Univ.	118	1,302.8	158	1,762.3	162	1,794.5	185	1,917.0	185	1,917.0
SIC 91-97 Government/ Military	57	607.3	77	1,076.8	79	1,079.0	91	1108.4	94	1142.7
Commercial	**1061**	**5,394.2**	**1350**	**7,200.6**	**1385**	**7,817.6**	**1534**	**8,987.1**	**1540**	**9,024.1**

Industrial

	1995		1999		2000		2003		2004	
	Sites	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**	**Sites**	**MW**
SIC 20: Food	175	3,864.5	192	5,363.4	202	5,446.0	218	6,107.6	218	6,107.6
SIC 26: Paper	227	10,189.8	242	10,966.7	246	11,294.1	254	12,347.9	254	12,347.9
SIC 28: Chemicals	205	16,841.8	227	19,491.9	241	21,273.9	263	26,115.2	264	26,579.2
SIC 29: Petroleum Refining	80	6,466.6	87	7,384.7	89	7,432.2	95	9,441.6	97	10,041.6
SIC: 33 Metals	35	2,897.9	41	3,341.9	42	3,349.6	46	3,906.7	46	3,906.7
SIC 34-39 Fabrication	94	1,406.1	106	1,505.1	114	1,816.4	120	3,092.0	121	3,096.5
Industrial	**981**	**44,966.4**	**1070**	**51,437.7**	**1114**	**54,005.8**	**1185**	**63,812.0**	**1189**	**65,611.7**

CHP Facility Database – Ongoing Work

- Web accessible version - November
  - Basic data
  - Linked to EEA state regulatory database
- CHP development trends analysis – December
  - Report outlining recent CHP growth
  - By application, prime mover, fuel, size and region

CHP Permitting and Regulatory Requirements Database

- Overview: Document state by state regulatory requirements for CHP projects. Incorporate into existing DG requirements database.
- Deliverable: On-line reference database. Possible topical reports.

Regulatory Database for Small Generators

- Contains state-by-state data on:

Environmental permitting

Siting regulations

Reporting requirements

Standby rates

Building codes

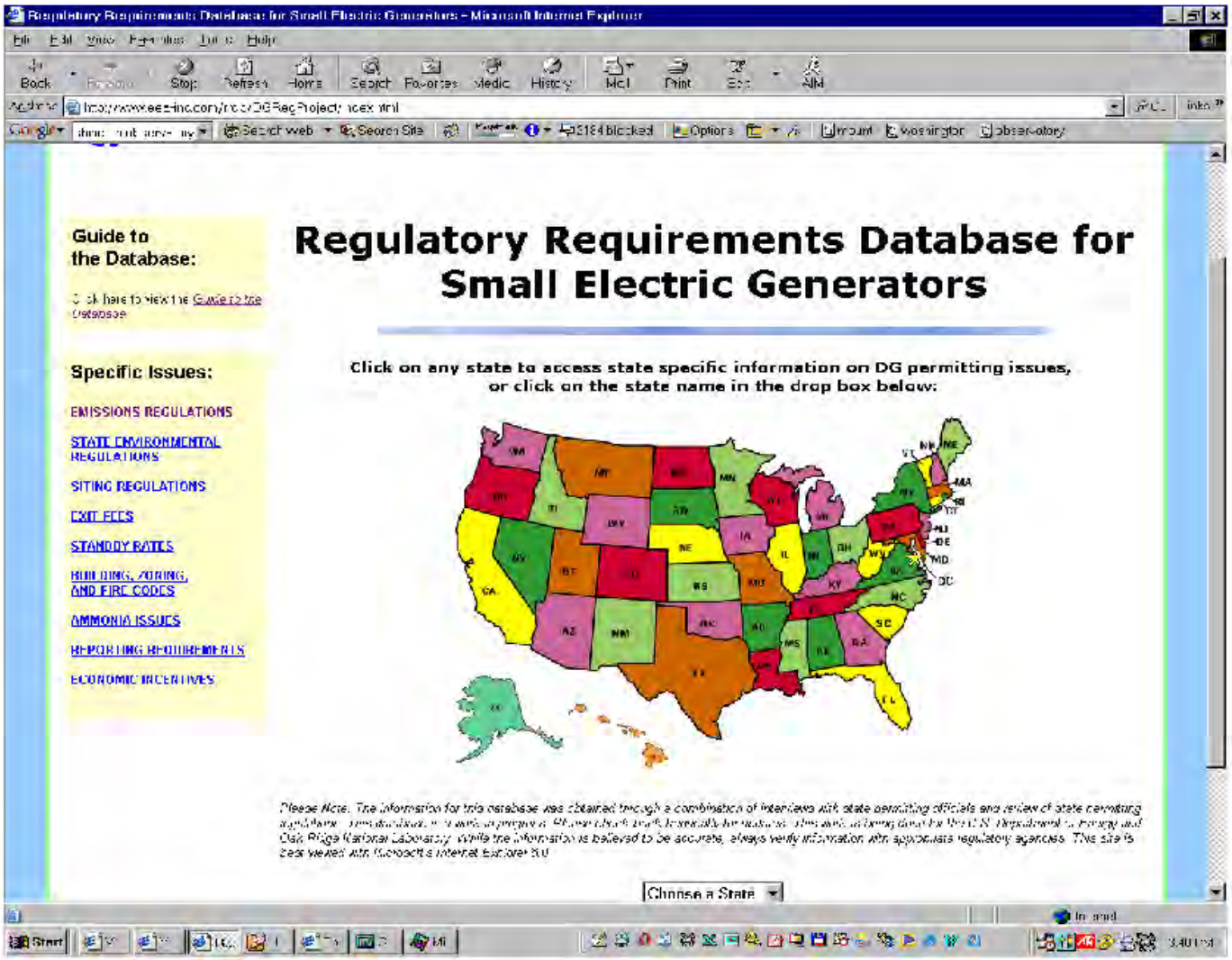
Exit fees/standby rates

CHP Incentives

Links to relevant state agencies

- Starting to develop interconnection data.
- Available at www.eea-inc.com

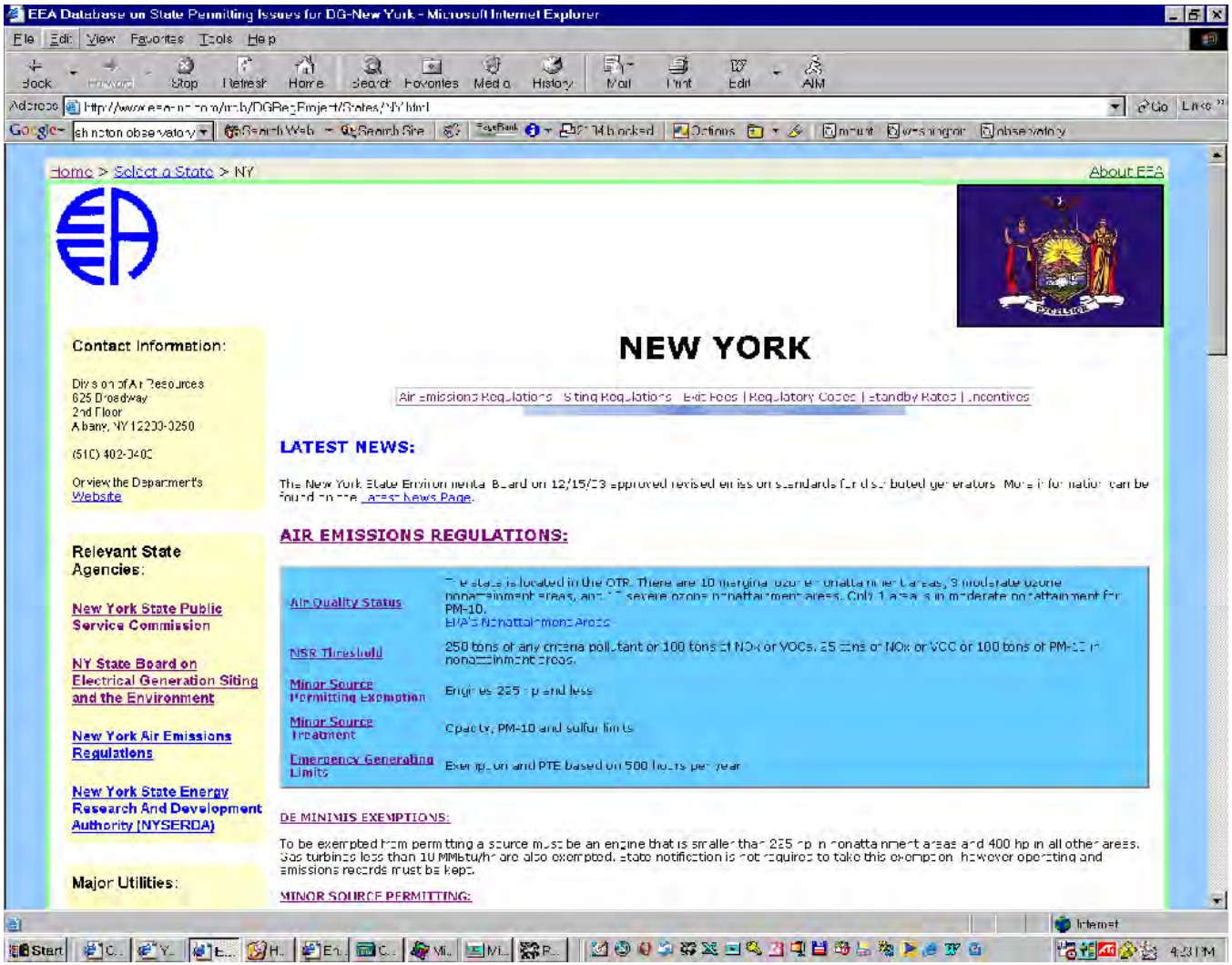
Regulatory Requirements Database



Environmental Regulatory Data

- Overview of each state's approach to regulation of small generators.
- Tracking of development of new DG regulations.
- Email notification service on new rule development.

Sample State Data Page



Further Work - RRDB

- Update and maintain the data
- Interconnection data - the big missing piece
- Analysis of the data:
  - Data provide a useful resource for developers but could also be the basis for some important policy analysis
  - Overview and analysis of emission regs, siting treatment, codes, standby rates.
  - Could support one large or several smaller reports with recommendations.

CHP Emissions/Credit Calculator

- Overview: Develop simple but accurate analytical tool to allow calculation of environmental benefits of CHP.
- Coordination: Work with developers and regulators/analysts projecting environmental impacts of CHP.
- Deliverable: Spreadsheet tool and documentation.

Emissions Calculator Parameters

- Prime Mover
- Fuel
- Emission Rate
- Operating hours
- Displaced thermal and power emissions.

- Default values for all parameters
- Displaced power emissions based on eGrid
- User can provide alternative values for all parameters

Emission Calculator Parameters

Prime Mover	Turbine, Oil/Gas Recip, Microturbine, Fuel Cell
Pollutants	NO_x, SO_2, Hg, CO_2
Fuel	Gas, diesel, distillate, coal boiler