

# Wind and Photovoltaic Assumptions

# Methodology for Estimating Energy (kWh) Benefits of Wind and PV projects

- For renewable resource scenario
  - Total amount of on-peak capacity assumed to be needed from investment in renewable capacity (i.e., 5400 MW)
    - Onshore wind, Offshore wind, Photo-voltaic (PV), Combined Heat and Power (CHP), Fuel Cells, Biomass, Landfill Gas, Small Hydro
    - 675 MW of each renewable resource type
  - Given that amount of capacity, quantify the amount and pattern of energy production across the hours/months of a year
  - Wind and Photo-voltaic resources are unique
    - Energy production cannot be scheduled
    - Energy available based on weather
  - Composite wind generation and PV profiles developed from actual wind and solar data from various sites in New England

# Stakeholder Comments

- Comments received by stakeholders
  - Recommended using more typical sites
    - Previously, selected sites believed to be atypical for assessment of widespread New England on-shore wind potential
  - Recommended using more conservative “wind scaling”
    - Scaling used to account for higher turbines than the anemometer
    - Previously, used
      - Measurements at different heights
      - Calculated site specific scaling factors
    - Now using “conventional wisdom”  $1/7^{\text{th}}$  wind scaling exponent
  - Recommended using more conservative hub heights than previous assumptions
  - Recommended accounting for wind turbine equipment outages and distribution “collection” losses

# Revised Renewable Energy Profiles

- Revised wind data
  - Prepared by Levitan and Associates
  - Wind data review part of larger New England wind potential assessment
  - Data developed from a single year: 2005
  - Preliminary results for two inland sites
    - Mt Tom
    - Paxton (west of Worcester)
  - Preliminary results for three offshore sites
    - Buzzards Bay
    - Bishop and Clerks islands
    - Isle of Shoals (offshore NH)
- No change to Photovoltaic data

# Observations on Wind Profiles Studies

- Focus for scenario analysis' wind energy assumption:
  - Energy production from wind (i.e., number of MWh of wind output)
    - Profile is embedded into the production simulation modeling
  - Some wind energy is included in the “common” resource assumptions that are similar across all scenarios
  - Wind energy is specifically evaluated in the Renewable Energy scenario
- Production simulation treatment of wind:
  - A certain amount is assumed in each hour of the year
  - To simulate energy output from wind resource, need 8760 hour per year
    - Daily (24 hour) profiles
    - For each month
  - Capture expected monthly characteristics across a year
  - The amount is tied to time-of-day and month-of-year energy profiles for wind based on actual wind data

# Wind Profiles and Capacity Value

- Base “capacity value” (CV) of wind is used in two ways
  - First: In the simulation runs, to set the total kWh from wind
  - Second: In the post-processing, to determine an amount of nameplate wind capacity needed to produce that wind energy
    - In “user spreadsheet tools,” allow the user to vary the CV assumption and relative capacity costs
- “Capacity value” (CV) has been discussed previously
  - Initially assumed 20 percent
  - Now using Forward Capacity Market (FCM) “Qualified Capacity” methodology
  - FCM capacity value based on Levitan wind study profiles
    - 19 percent for onshore
    - 26 percent for offshore

# Installed Nameplate MW

- Need to determine amount of nameplate wind turbine capacity to add:
  - Renewable Scenario assumes
  - 1/8 of the inc'l 5400 MW of capacity comes from inland wind
  - 1/8 of the inc'l 5400 MW of capacity comes from off-shore wind
- Depending upon the assumed ratio of MWh output to MW size (i.e., the output ratio), different nameplate MW will produce different MWh output levels

# Installed Nameplate MW

- To obtain 675 MW of “needed capacity” from the resource need to add more to get “effective” capacity:
  - 3,484 “effective” MW for inland (assumed 19% CV)
  - 2,598 “effective” MW nameplate for offshore (assumed 26% CV)
  - 2,092 “effective” MW for PV (assumed 40% CV)
- Effect of 90 percent mechanical availability and distribution losses
  - 3,871 MW nameplate for inland wind
  - 2,886 MW nameplate for offshore wind
- Effect of 98 percent assumed PV availability
  - 1,681 MW nameplate for PV

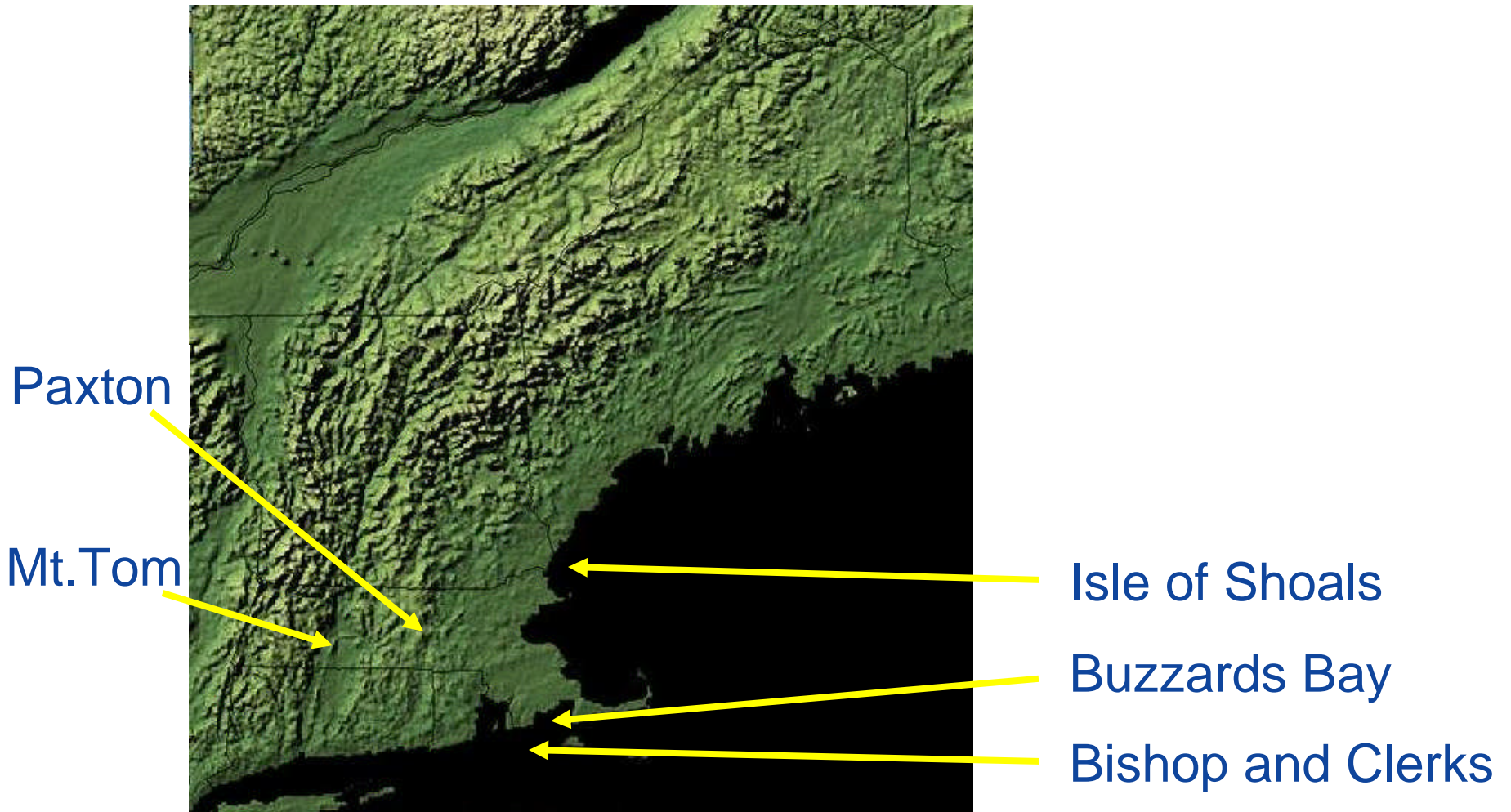
# Observations Regarding PV Profile

- Similar conceptual framework is used for determining the amount of MWh from PV facilities
  - Use of solar data to estimate hourly profile of solar energy for each month
  - Assume 675 MW of needed capacity (1/8 of incremental 5400 MW) is from PV
  - Use this amount of MW, along with CV and to determine:
    - Effective capacity
    - Finally 98 percent availability used to determine nameplate MW
    - Profile for these MW used to develop number of MWh generated

# Overview of Study of Wind and PV Profiles

- **PV systems also evaluated; preliminary results for 2 sites**
  - Hartford
  - Boston
- **Data from sites used as proxies for renewable projects, not actual output from individual plants**

# Location of Wind Sites Investigigated



Source: <http://nmviewogc.cr.usgs.gov/viewer.htm>

# Development of Composite Wind Profiles

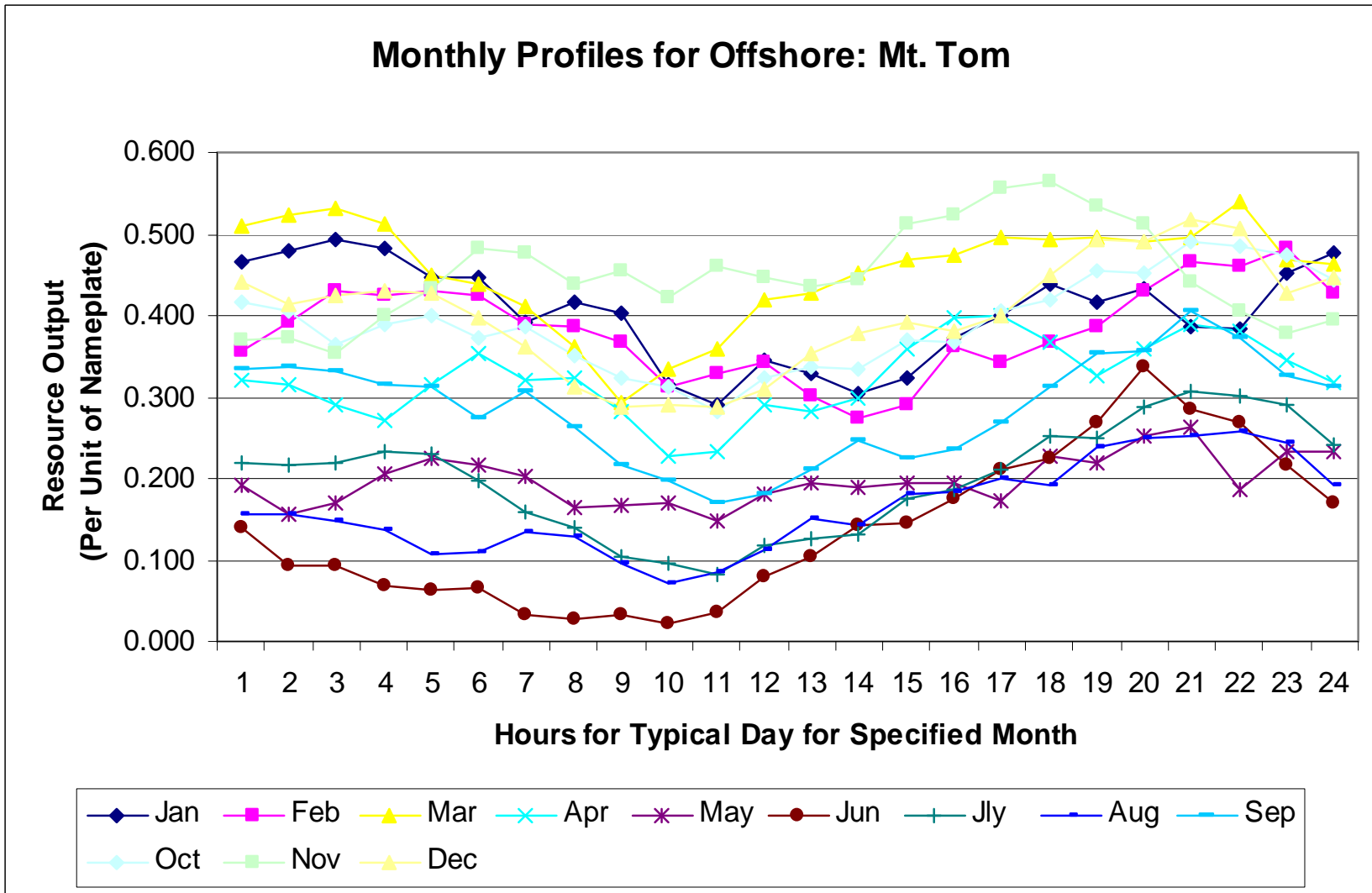
- Onshore and Offshore profiles based are composites
- Installed wind based on summer FCM capacity values
  - Needed to attain 675 MW of FCM qualified capacity
  - Variability of winds requires more “effective” capacity to get 675 MW
  - “Effective” capacity assumes 100 percent mechanical availability
    - Assuming 90 percent availability requires 11 percent more installed nameplate MWs for get effective capacity

Summer							Winter		
Site	FCM Qual	Fraction	Composite	Needed	Effective	Nameplate	FCM Qual	Fraction	Composite
<b>Onshore</b>									
Mt Tom	0.202	0.500					0.415	0.500	
Paxton	0.185	0.500	0.194	675	3484	3871	0.410	0.500	0.413
<b>Offshore</b>									
BUZM3	0.259	0.333	0.260	675	2598	2886	0.490	0.333	0.459
Isle of Shoals	0.223	0.333					0.446	0.333	
Bishop and Clerks (BC)	0.297	0.333					0.442	0.333	

# Mt Tom – Wind Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	
1	0.467	0.355	0.511	0.320	0.191	0.141	0.219	0.157	0.333	0.417	0.369	0.441	
2	0.480	0.390	0.524	0.316	0.155	0.093	0.216	0.156	0.336	0.407	0.373	0.414	
3	0.494	0.429	0.532	0.290	0.171	0.092	0.220	0.148	0.332	0.364	0.353	0.425	
4	0.482	0.423	0.513	0.272	0.206	0.068	0.232	0.137	0.315	0.388	0.401	0.431	
5	0.446	0.429	0.450	0.315	0.224	0.063	0.231	0.108	0.312	0.400	0.432	0.428	
6	0.447	0.425	0.439	0.352	0.217	0.065	0.198	0.109	0.273	0.373	0.483	0.396	
7	0.393	0.390	0.412	0.322	0.202	0.033	0.160	0.134	0.308	0.386	0.476	0.360	
8	0.418	0.387	0.361	0.324	0.165	0.028	0.141	0.130	0.263	0.351	0.437	0.313	
9	0.404	0.367	0.294	0.282	0.166	0.032	0.105	0.096	0.217	0.325	0.456	0.287	
10	0.314	0.311	0.333	0.226	0.169	0.022	0.096	0.072	0.199	0.312	0.421	0.289	
11	0.290	0.328	0.359	0.232	0.149	0.036	0.081	0.085	0.169	0.284	0.460	0.288	
12	0.345	0.343	0.420	0.289	0.182	0.079	0.118	0.113	0.181	0.323	0.447	0.311	
13	0.330	0.302	0.426	0.282	0.194	0.104	0.127	0.152	0.211	0.337	0.435	0.353	
14	0.303	0.274	0.452	0.297	0.190	0.1424	0.1314	0.1422	0.2471	0.334	0.444	0.377	
15	0.324	0.289	0.468	0.359	0.195	0.1455	0.1741	0.1810	0.2254	0.371	0.512	0.393	
16	0.372	0.360	0.473	0.396	0.195	0.1766	0.1867	0.1843	0.2353	0.368	0.524	0.381	
17	0.401	0.343	0.497	0.401	0.173	0.2115	0.2118	0.2004	0.2672	0.406	0.556	0.401	
18	0.438	0.367	0.494	0.368	0.226	0.2239	0.2523	0.1927	0.3115	0.418	0.565	0.448	
19	0.417	0.386	0.495	0.327	0.218	0.267	0.248	0.239	0.353	0.455	0.534	0.492	
20	0.432	0.430	0.491	0.359	0.253	0.337	0.287	0.249	0.357	0.451	0.511	0.489	
21	0.386	0.465	0.496	0.389	0.262	0.286	0.306	0.253	0.406	0.492	0.442	0.519	
22	0.383	0.460	0.539	0.380	0.185	0.269	0.302	0.258	0.373	0.484	0.406	0.506	
23	0.453	0.481	0.469	0.345	0.232	0.215	0.291	0.244	0.326	0.474	0.378	0.427	
24	0.478	0.428	0.463	0.319	0.234	0.170	0.240	0.193	0.312	0.444	0.395	0.446	
	0.404	0.382	0.455	0.323	0.198	0.138	0.199	0.164	0.286	0.390	0.450	0.401	
	Average Summer Capacity Value			0.2022			Annual Capacity Factor with 100 percent Mechanical Availability					0.316	
	Average Winter Capacity Value			0.4155									

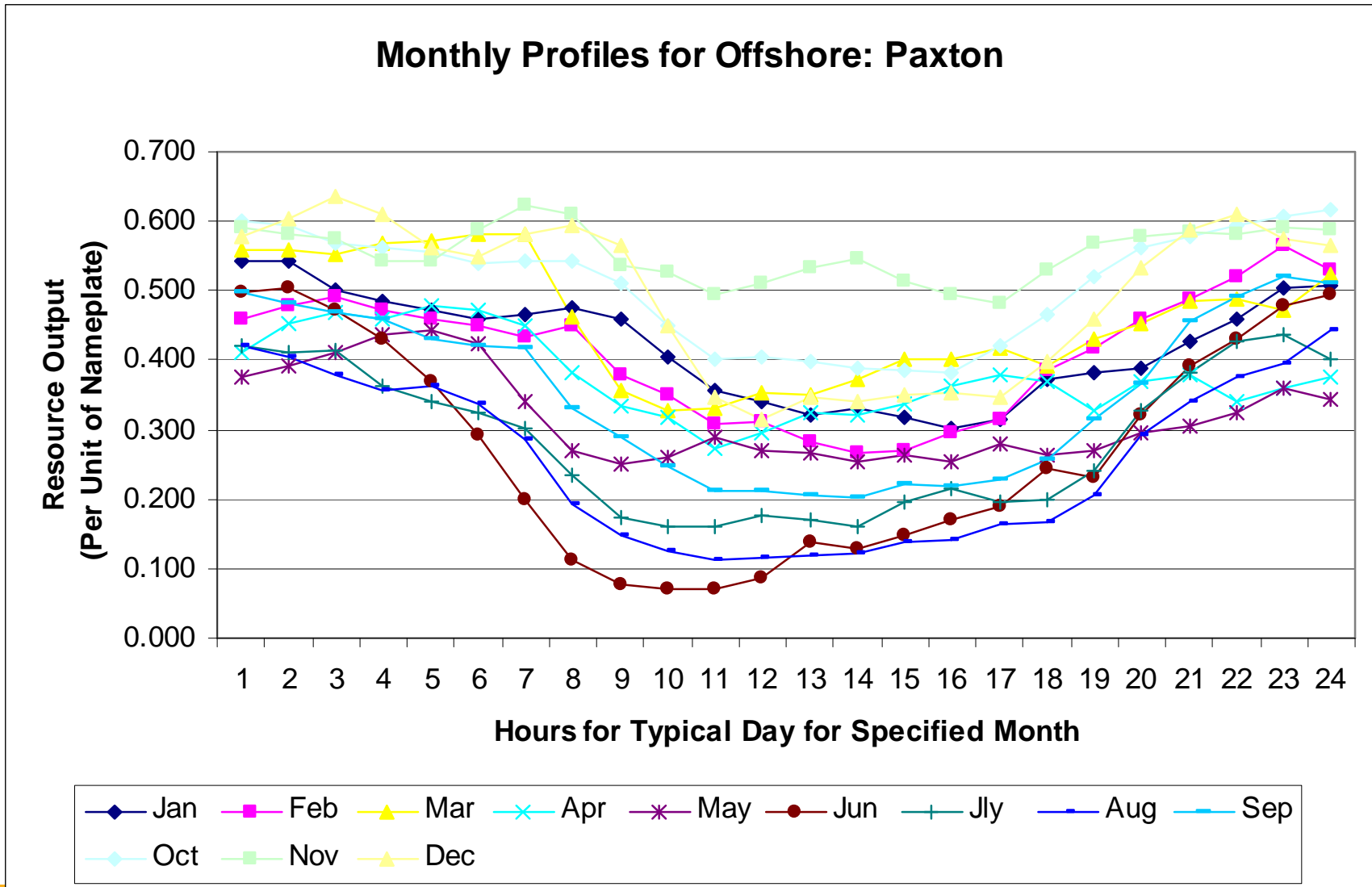
# Mt Tom – Wind Profile



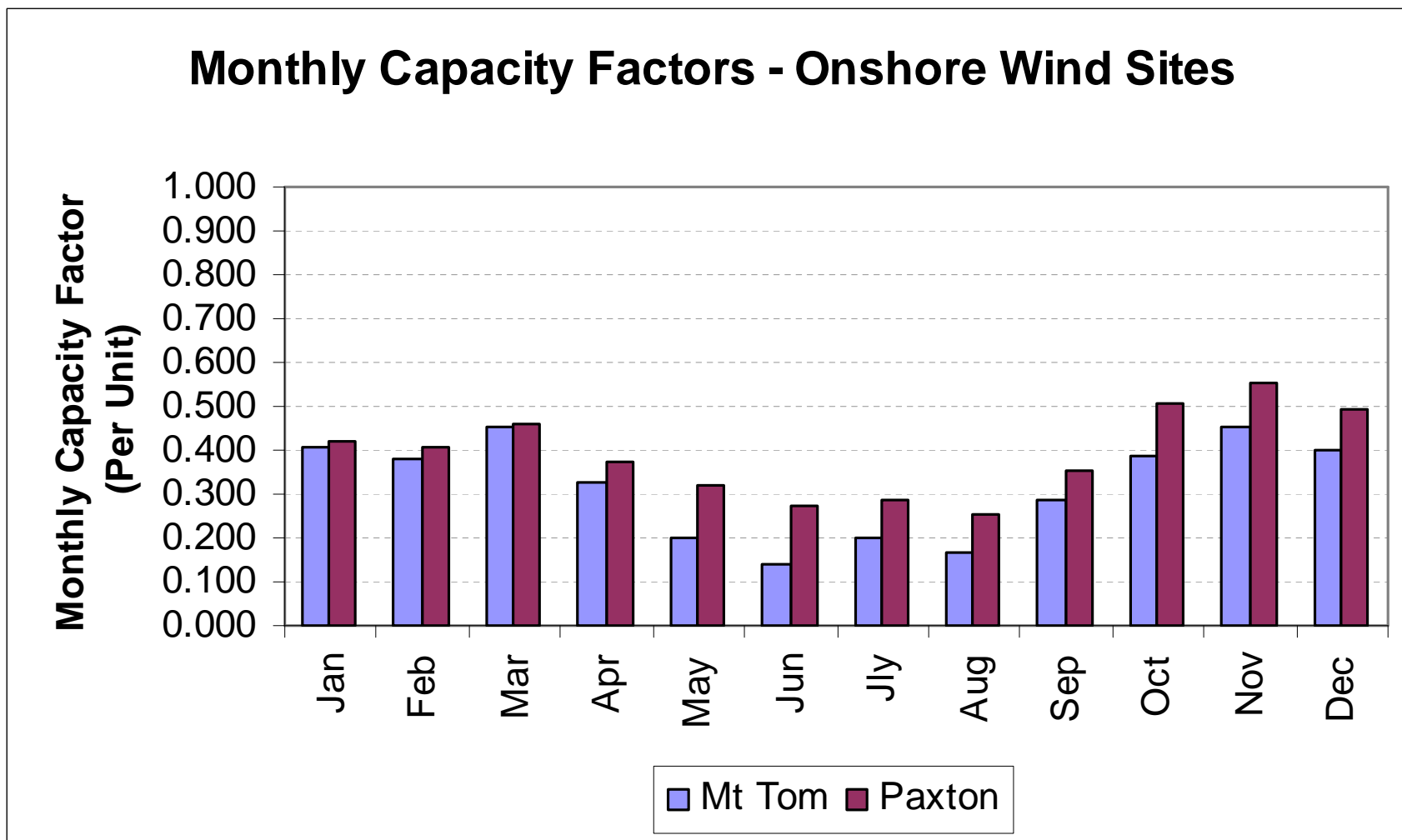
# Paxton – Wind Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec		
1	0.544	0.460	0.559	0.411	0.376	0.499	0.419	0.421	0.499	0.602	0.592	0.578		
2	0.543	0.477	0.558	0.453	0.390	0.503	0.410	0.404	0.481	0.593	0.581	0.605		
3	0.501	0.493	0.553	0.468	0.411	0.471	0.414	0.378	0.469	0.567	0.576	0.635		
4	0.486	0.471	0.568	0.460	0.436	0.431	0.364	0.357	0.459	0.563	0.541	0.609		
5	0.471	0.459	0.571	0.479	0.444	0.370	0.339	0.363	0.432	0.554	0.543	0.563		
6	0.460	0.450	0.581	0.473	0.424	0.293	0.324	0.338	0.419	0.540	0.589	0.549		
7	0.467	0.435	0.581	0.451	0.341	0.198	0.301	0.287	0.417	0.542	0.624	0.580		
8	0.476	0.449	0.464	0.382	0.268	0.112	0.235	0.191	0.331	0.542	0.610	0.595		
9	0.460	0.379	0.358	0.335	0.249	0.077	0.173	0.149	0.290	0.510	0.536	0.565		
10	0.404	0.351	0.326	0.318	0.261	0.069	0.160	0.125	0.247	0.450	0.527	0.449		
11	0.358	0.310	0.331	0.273	0.290	0.072	0.160	0.114	0.212	0.400	0.494	0.348		
12	0.339	0.312	0.353	0.295	0.269	0.086	0.176	0.117	0.213	0.405	0.510	0.314		
13	0.320	0.282	0.352	0.324	0.266	0.139	0.169	0.118	0.204	0.399	0.532	0.348		
14	0.330	0.266	0.372	0.322	0.253	0.1282	0.1611	0.1219	0.2016	0.390	0.547	0.341		
15	0.319	0.270	0.402	0.337	0.262	0.1482	0.1953	0.1389	0.2230	0.386	0.513	0.349		
16	0.302	0.294	0.401	0.361	0.255	0.1700	0.2155	0.1397	0.2191	0.383	0.496	0.352		
17	0.314	0.314	0.418	0.379	0.279	0.1909	0.1945	0.1636	0.2272	0.421	0.481	0.347		
18	0.373	0.384	0.393	0.369	0.263	0.2450	0.1999	0.1668	0.2569	0.467	0.529	0.399		
19	0.382	0.418	0.430	0.327	0.271	0.232	0.241	0.205	0.316	0.522	0.570	0.458		
20	0.389	0.458	0.452	0.368	0.294	0.320	0.328	0.291	0.365	0.561	0.577	0.534		
21	0.428	0.489	0.486	0.377	0.306	0.390	0.382	0.339	0.457	0.577	0.584	0.587		
22	0.461	0.519	0.487	0.342	0.326	0.431	0.427	0.375	0.492	0.595	0.580	0.609		
23	0.503	0.564	0.471	0.359	0.358	0.479	0.438	0.394	0.522	0.607	0.590	0.576		
24	0.507	0.529	0.522	0.375	0.345	0.495	0.403	0.442	0.512	0.615	0.589	0.566		
	0.422	0.410	0.458	0.377	0.318	0.273	0.285	0.256	0.353	0.508	0.555	0.494		
	Average Summer Capacity Value			0.1854			Annual Capacity Factor with 100 percent Mechanical Availability					0.392		
	Average Winter Capacity Value			0.4096										

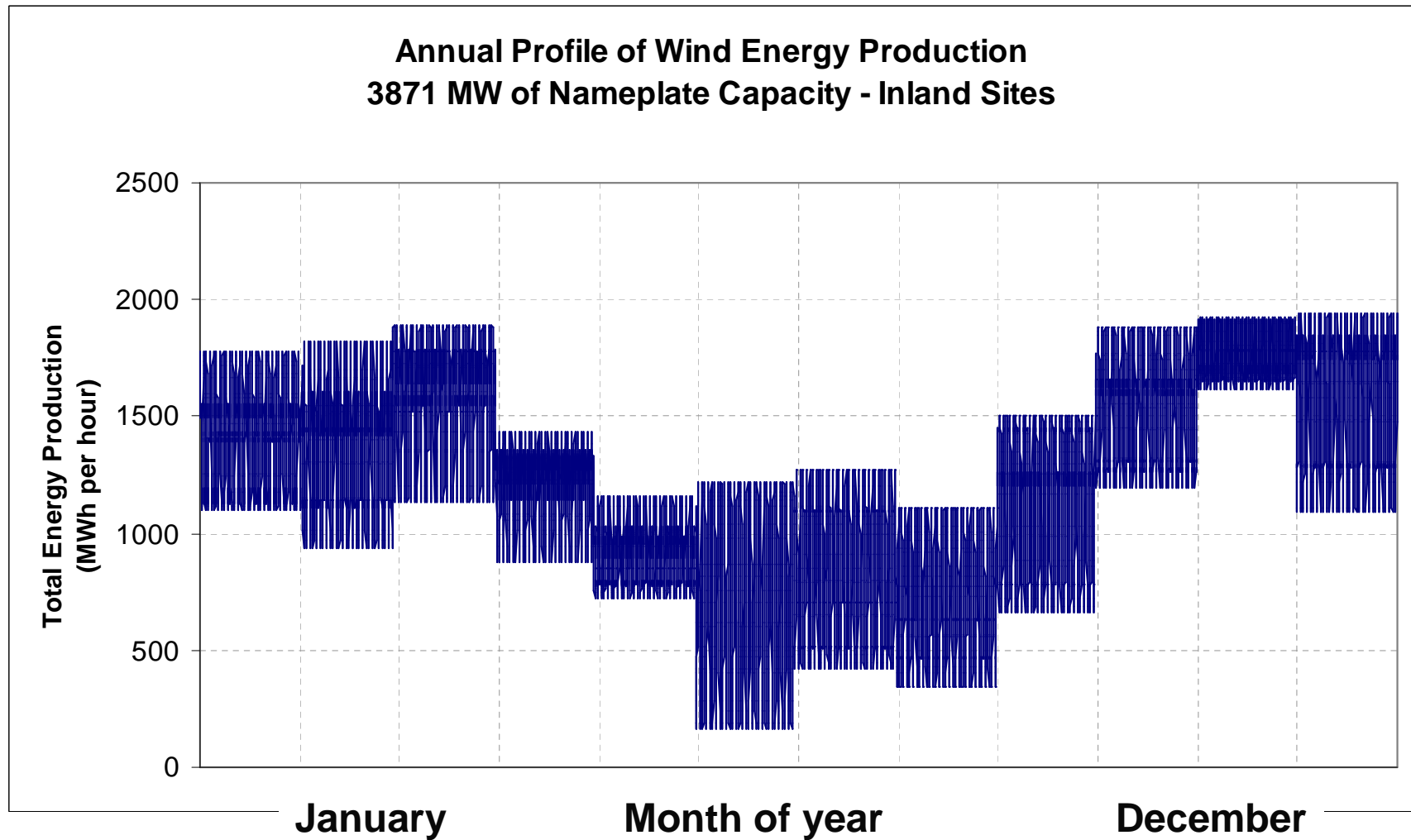
# Paxton – Wind Profile



# Monthly Capacity Factors – Onshore Wind (by month of year)



# Annual Onshore Wind Generation Profile (by month of year)

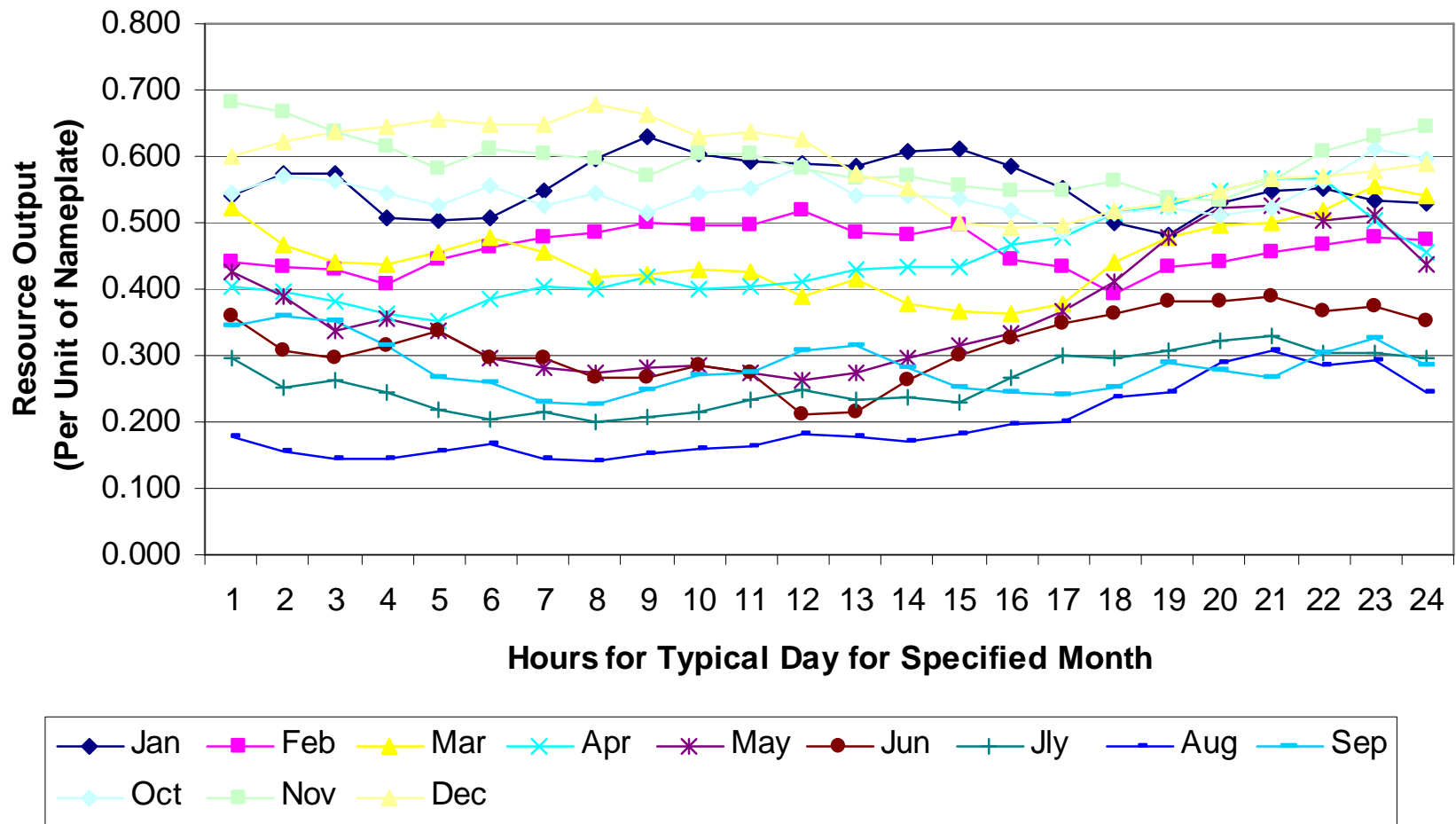


# Buzzards Bay – Wind Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec		
1	0.540	0.442	0.523	0.403	0.427	0.361	0.297	0.178	0.344	0.544	0.681	0.601		
2	0.576	0.433	0.467	0.396	0.389	0.309	0.252	0.156	0.361	0.570	0.668	0.622		
3	0.573	0.428	0.441	0.381	0.336	0.298	0.263	0.144	0.353	0.562	0.636	0.638		
4	0.507	0.406	0.436	0.363	0.354	0.314	0.246	0.145	0.315	0.543	0.614	0.643		
5	0.505	0.443	0.456	0.352	0.337	0.336	0.220	0.157	0.266	0.525	0.581	0.654		
6	0.506	0.463	0.477	0.387	0.298	0.295	0.203	0.166	0.259	0.555	0.611	0.648		
7	0.549	0.478	0.457	0.403	0.280	0.296	0.215	0.143	0.228	0.527	0.604	0.647		
8	0.597	0.487	0.418	0.400	0.275	0.267	0.201	0.139	0.227	0.543	0.594	0.676		
9	0.628	0.501	0.423	0.420	0.283	0.268	0.209	0.151	0.249	0.515	0.572	0.665		
10	0.602	0.497	0.430	0.402	0.285	0.284	0.216	0.160	0.270	0.544	0.605	0.630		
11	0.591	0.498	0.426	0.404	0.272	0.274	0.233	0.162	0.273	0.553	0.603	0.636		
12	0.590	0.518	0.391	0.410	0.262	0.210	0.247	0.180	0.307	0.587	0.583	0.625		
13	0.584	0.484	0.414	0.428	0.274	0.214	0.234	0.179	0.315	0.542	0.568	0.575		
14	0.607	0.482	0.376	0.432	0.297	0.2618	0.2359	0.1698	0.2807	0.541	0.571	0.553		
15	0.612	0.495	0.366	0.434	0.316	0.3008	0.2307	0.1832	0.2509	0.536	0.556	0.498		
16	0.583	0.443	0.362	0.466	0.335	0.3257	0.2678	0.1958	0.2432	0.517	0.549	0.491		
17	0.552	0.434	0.377	0.479	0.367	0.3478	0.2993	0.2014	0.2417	0.487	0.547	0.496		
18	0.500	0.393	0.440	0.514	0.411	0.3645	0.2955	0.2359	0.2536	0.513	0.562	0.518		
19	0.483	0.431	0.479	0.526	0.476	0.381	0.306	0.245	0.291	0.520	0.539	0.529		
20	0.530	0.440	0.497	0.549	0.522	0.381	0.324	0.287	0.277	0.511	0.534	0.548		
21	0.550	0.456	0.499	0.566	0.526	0.389	0.328	0.307	0.266	0.524	0.561	0.567		
22	0.551	0.465	0.519	0.567	0.504	0.366	0.304	0.287	0.306	0.565	0.606	0.570		
23	0.535	0.477	0.557	0.504	0.511	0.372	0.302	0.292	0.325	0.612	0.628	0.578		
24	0.528	0.475	0.540	0.457	0.438	0.352	0.296	0.244	0.286	0.595	0.644	0.590		
	0.557	0.461	0.449	0.443	0.366	0.315	0.259	0.196	0.283	0.543	0.592	0.591		
	Average Summer Capacity Value			0.2593			Annual Capacity Factor with 100 percent Mechanical Availability					0.421		
	Average Winter Capacity Value			0.4896										

# Buzzard's Bay – Wind Profile

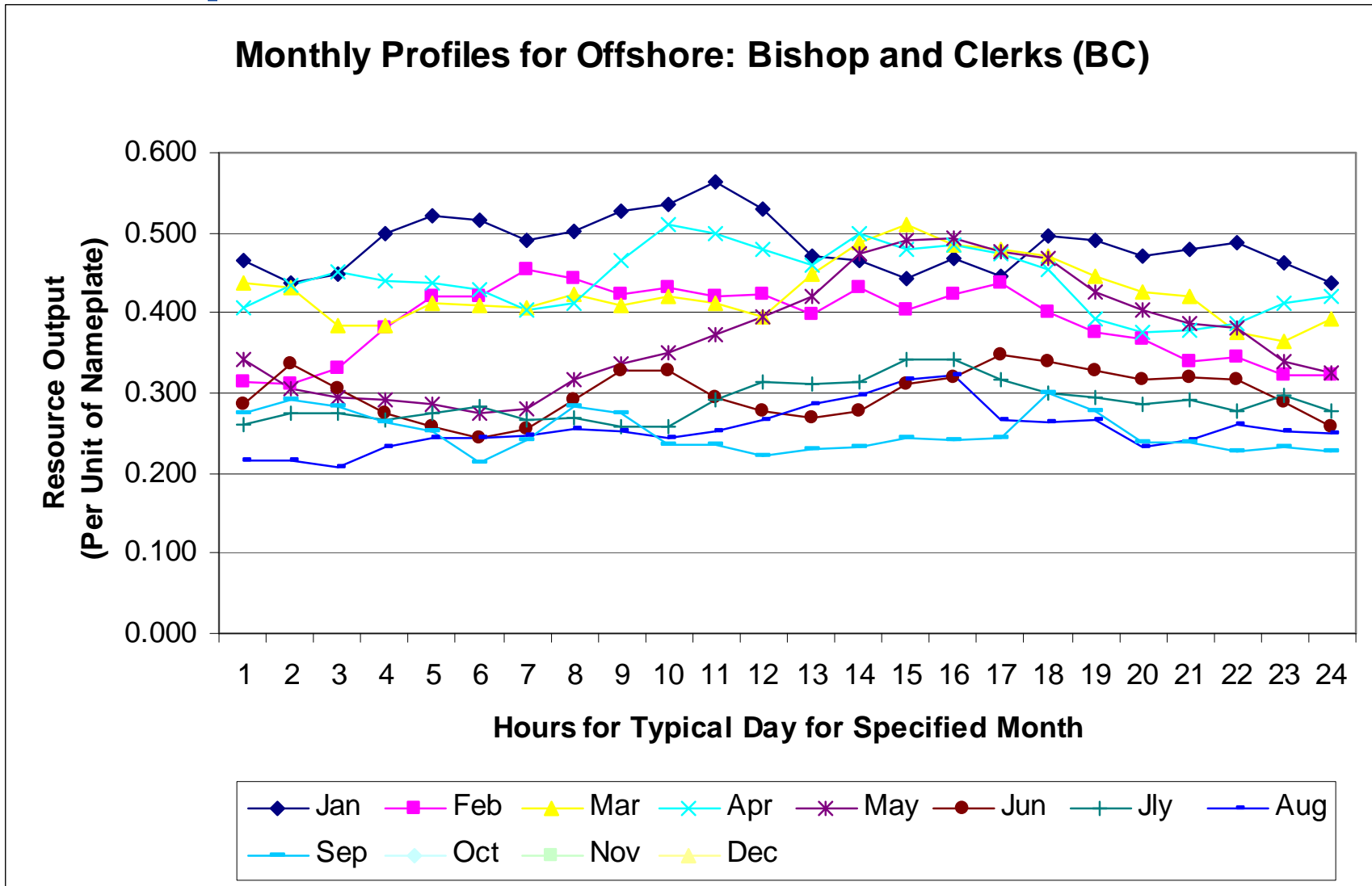
## Monthly Profiles for Offshore: BUZM3



# Bishop's and Clerks – Wind Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	
1	0.466	0.314	0.438	0.408	0.341	0.286	0.262	0.217	0.276				
2	0.436	0.310	0.433	0.434	0.306	0.336	0.274	0.216	0.291				
3	0.449	0.331	0.385	0.451	0.295	0.305	0.275	0.207	0.282				
4	0.500	0.381	0.384	0.441	0.292	0.275	0.265	0.234	0.263				
5	0.523	0.421	0.411	0.437	0.285	0.257	0.275	0.243	0.251				
6	0.515	0.420	0.408	0.430	0.276	0.243	0.284	0.245	0.213				
7	0.491	0.454	0.408	0.403	0.281	0.256	0.266	0.247	0.241				
8	0.503	0.442	0.423	0.413	0.317	0.291	0.269	0.254	0.285				
9	0.527	0.424	0.410	0.466	0.336	0.329	0.257	0.253	0.273				
10	0.535	0.432	0.421	0.509	0.350	0.327	0.259	0.245	0.237				
11	0.563	0.422	0.411	0.499	0.374	0.295	0.293	0.252	0.235				
12	0.531	0.424	0.394	0.481	0.396	0.279	0.314	0.265	0.221				
13	0.471	0.399	0.450	0.461	0.419	0.268	0.312	0.287	0.230				
14	0.465	0.432	0.487	0.498	0.475	0.2776	0.3136	0.2965	0.2314				
15	0.444	0.403	0.510	0.479	0.490	0.3113	0.3407	0.3160	0.2448				
16	0.468	0.423	0.485	0.485	0.494	0.3191	0.3408	0.3220	0.2410				
17	0.445	0.436	0.479	0.474	0.476	0.3488	0.3163	0.2667	0.2452				
18	0.495	0.401	0.470	0.454	0.470	0.3400	0.2994	0.2649	0.3013				
19	0.490	0.375	0.447	0.392	0.427	0.329	0.294	0.265	0.277				
20	0.471	0.367	0.427	0.375	0.403	0.318	0.287	0.233	0.237				
21	0.479	0.340	0.421	0.380	0.386	0.319	0.293	0.241	0.240				
22	0.488	0.345	0.375	0.386	0.381	0.316	0.278	0.262	0.226				
23	0.464	0.322	0.365	0.411	0.338	0.290	0.297	0.253	0.232				
24	0.438	0.323	0.393	0.421	0.325	0.259	0.276	0.250	0.226				
	0.486	0.389	0.426	0.441	0.372	0.299	0.289	0.256	0.250				
	Average Summer Capacity Value			0.2969		Annual Capacity Factor with 100 percent Mechanical Availability						0.356	
	Average Winter Capacity Value			0.4420									

# Bishop's and Clerks - Wind Profile

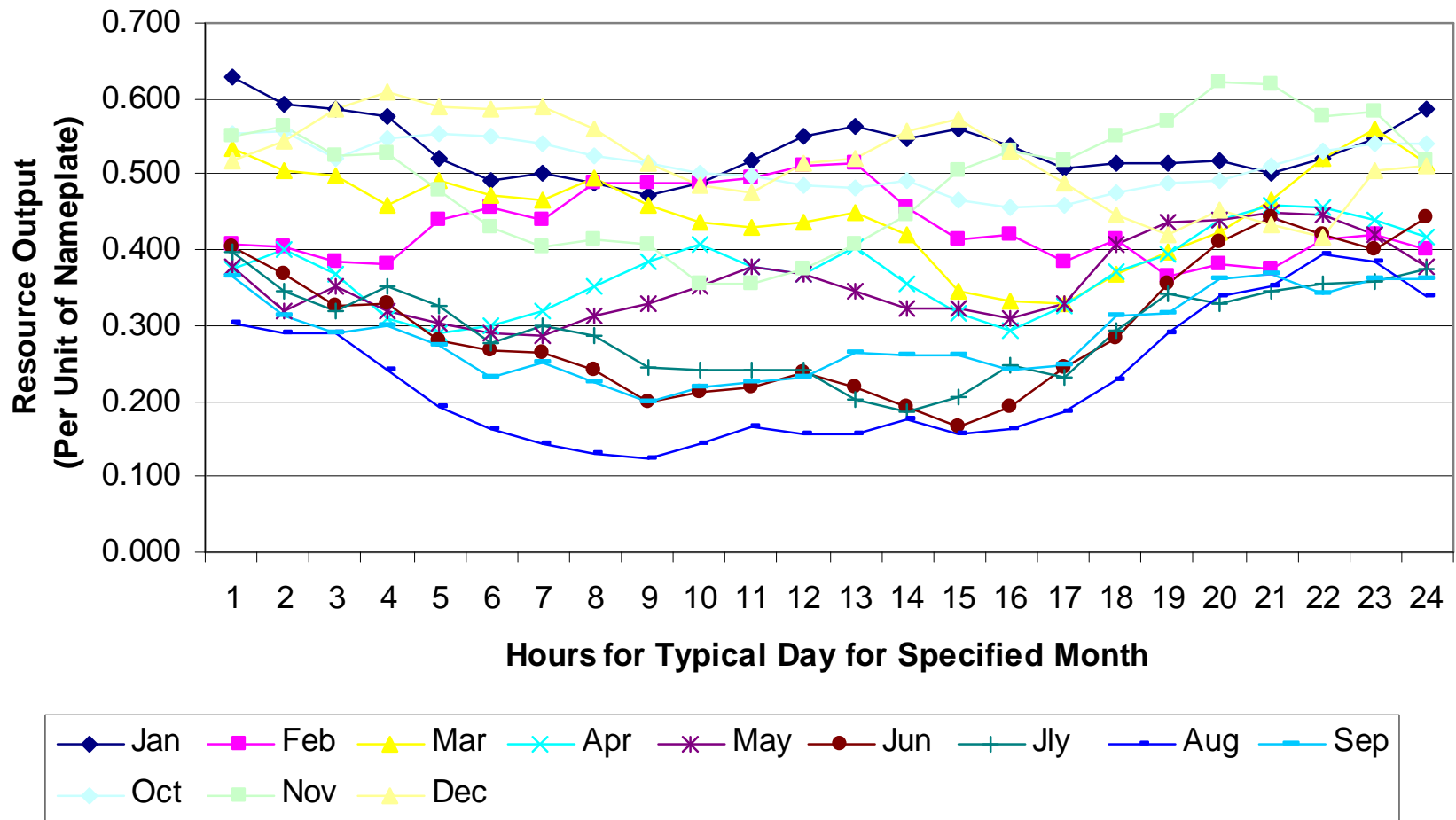


# Isle of Shoals - Wind Data

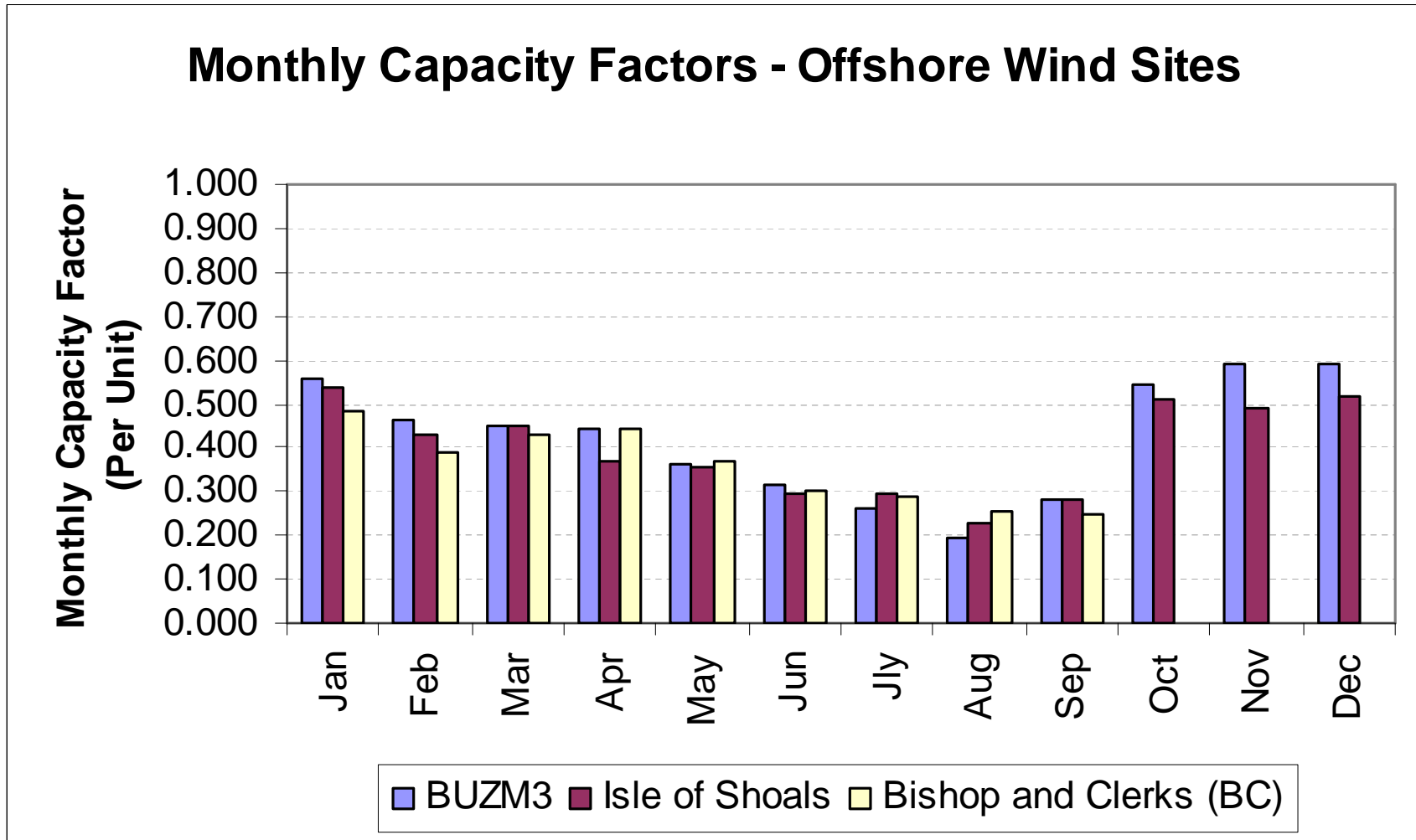
	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec		
1	0.628	0.407	0.535	0.374	0.378	0.404	0.397	0.303	0.365	0.553	0.549	0.518		
2	0.592	0.403	0.506	0.401	0.320	0.369	0.346	0.291	0.313	0.555	0.562	0.543		
3	0.585	0.384	0.497	0.369	0.352	0.325	0.319	0.291	0.289	0.520	0.524	0.585		
4	0.576	0.382	0.460	0.310	0.319	0.328	0.352	0.240	0.300	0.546	0.528	0.608		
5	0.522	0.438	0.490	0.289	0.304	0.279	0.326	0.193	0.272	0.553	0.479	0.589		
6	0.491	0.457	0.473	0.298	0.288	0.266	0.277	0.162	0.230	0.549	0.429	0.585		
7	0.501	0.440	0.465	0.320	0.286	0.264	0.298	0.142	0.250	0.542	0.405	0.589		
8	0.488	0.488	0.494	0.350	0.313	0.240	0.288	0.131	0.226	0.523	0.413	0.561		
9	0.472	0.488	0.459	0.386	0.327	0.200	0.246	0.125	0.198	0.515	0.408	0.514		
10	0.489	0.490	0.435	0.406	0.352	0.210	0.240	0.143	0.218	0.501	0.356	0.485		
11	0.518	0.494	0.431	0.377	0.377	0.217	0.240	0.167	0.224	0.497	0.356	0.476		
12	0.551	0.510	0.436	0.366	0.367	0.236	0.241	0.157	0.232	0.484	0.375	0.516		
13	0.562	0.514	0.449	0.404	0.345	0.220	0.203	0.158	0.264	0.483	0.407	0.522		
14	0.545	0.456	0.420	0.355	0.323	0.1924	0.1856	0.1752	0.2610	0.493	0.447	0.557		
15	0.560	0.413	0.346	0.315	0.323	0.1657	0.2048	0.1561	0.2606	0.466	0.504	0.573		
16	0.538	0.420	0.332	0.292	0.308	0.1933	0.2473	0.1627	0.2402	0.456	0.532	0.532		
17	0.508	0.383	0.328	0.324	0.327	0.2449	0.2296	0.1845	0.2487	0.459	0.518	0.488		
18	0.513	0.412	0.366	0.372	0.408	0.2830	0.2921	0.2276	0.3110	0.475	0.551	0.446		
19	0.515	0.366	0.396	0.394	0.437	0.356	0.343	0.289	0.317	0.490	0.570	0.420		
20	0.516	0.379	0.423	0.440	0.440	0.409	0.328	0.338	0.362	0.491	0.623	0.453		
21	0.502	0.375	0.465	0.458	0.449	0.444	0.346	0.352	0.369	0.512	0.620	0.435		
22	0.520	0.414	0.520	0.456	0.445	0.419	0.355	0.393	0.343	0.532	0.575	0.418		
23	0.546	0.420	0.560	0.441	0.420	0.401	0.357	0.384	0.362	0.541	0.584	0.505		
24	0.584	0.402	0.513	0.417	0.379	0.441	0.375	0.338	0.363	0.541	0.516	0.512		
	0.534	0.431	0.450	0.371	0.358	0.296	0.293	0.229	0.284	0.511	0.493	0.518		
	Average Summer Capacity Value			0.2233			Annual Capacity Factor with 100 percent Mechanical Availability					0.397		
	Average Winter Capacity Value			0.4457										

# Isle of Shoals - Wind Profile

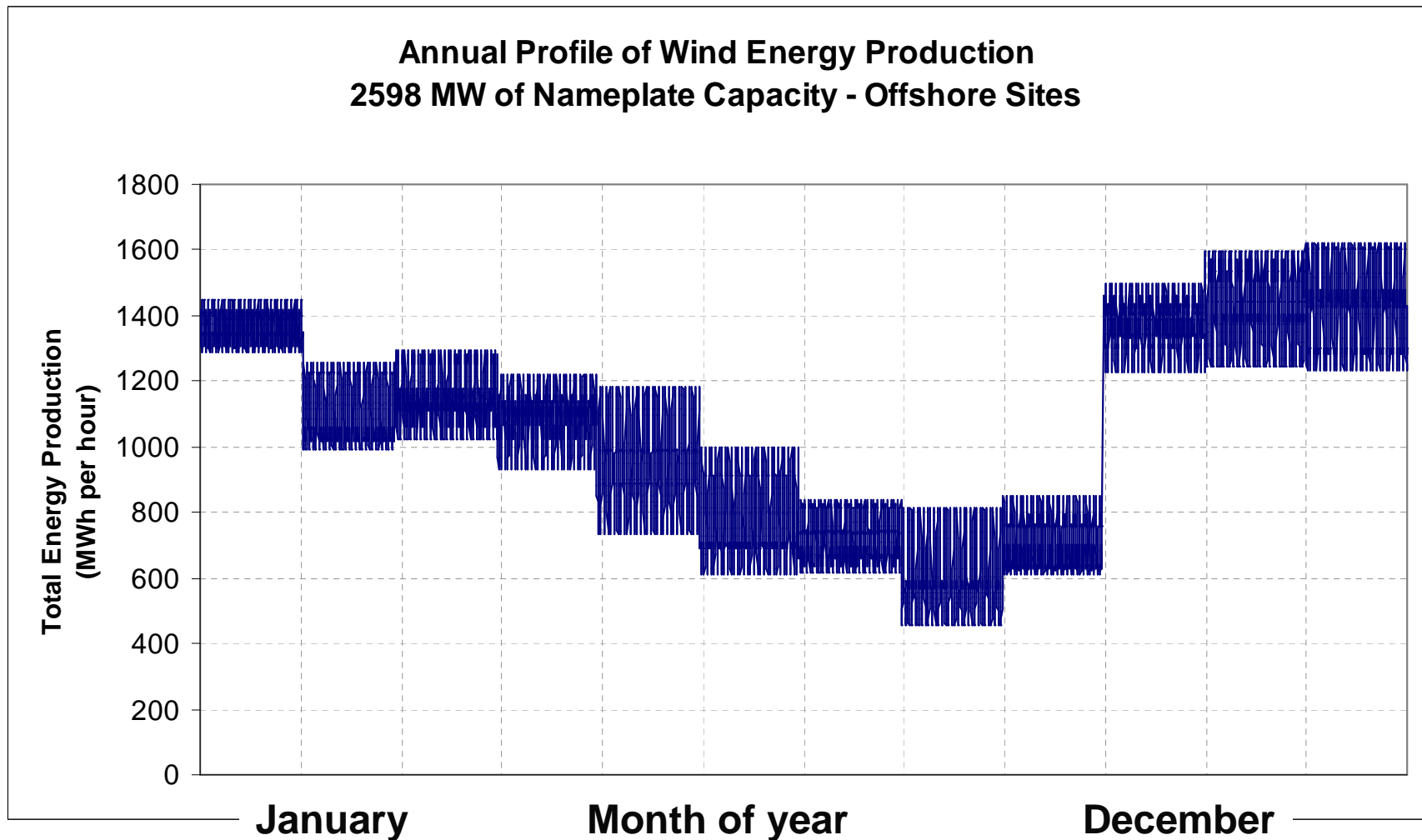
## Monthly Profiles for Offshore: Isle of Shoals



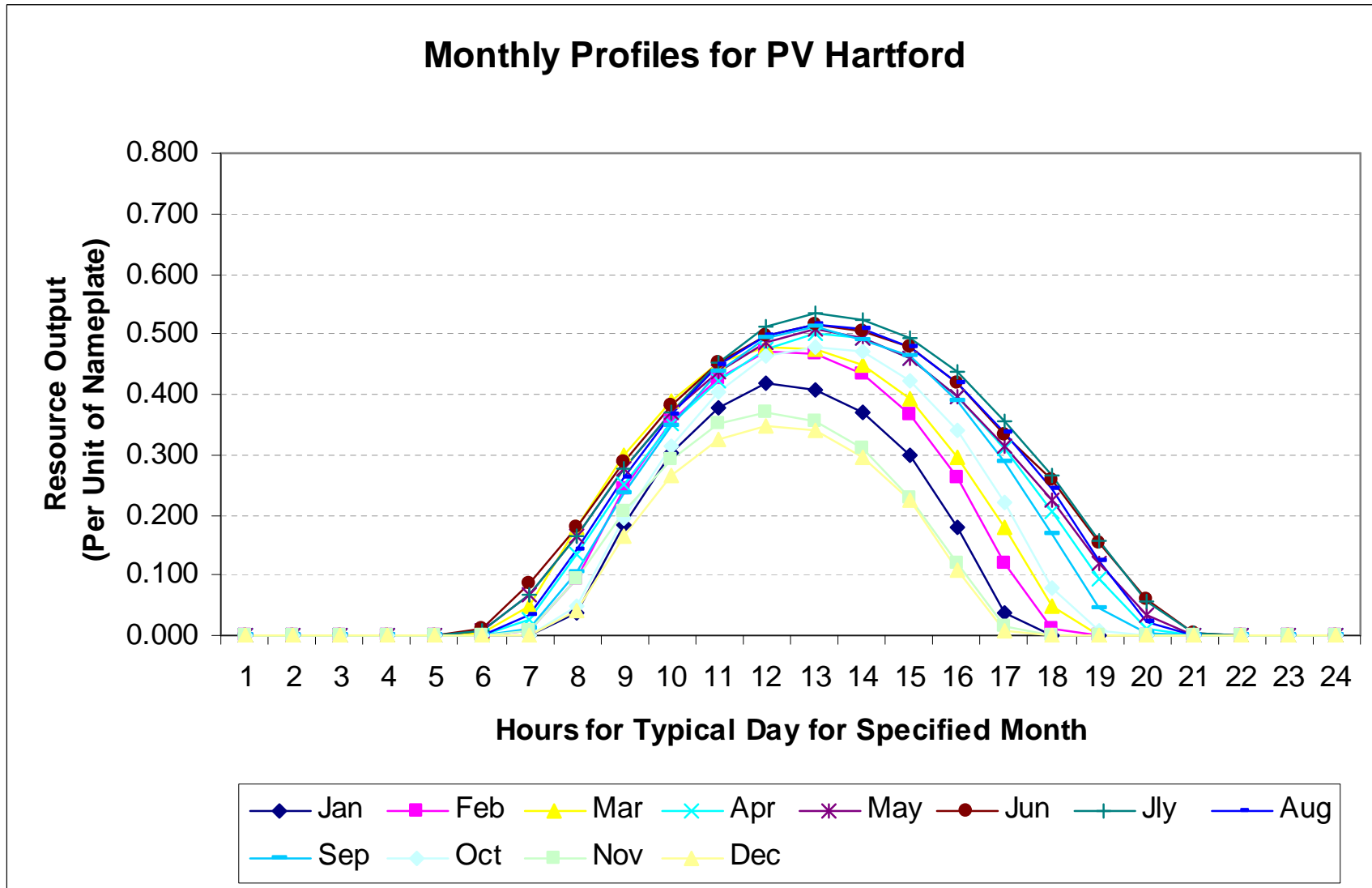
# Monthly Capacity Factors – Offshore Wind (by month of year)



# Annual Offshore Wind Generation Profile (by month of year)



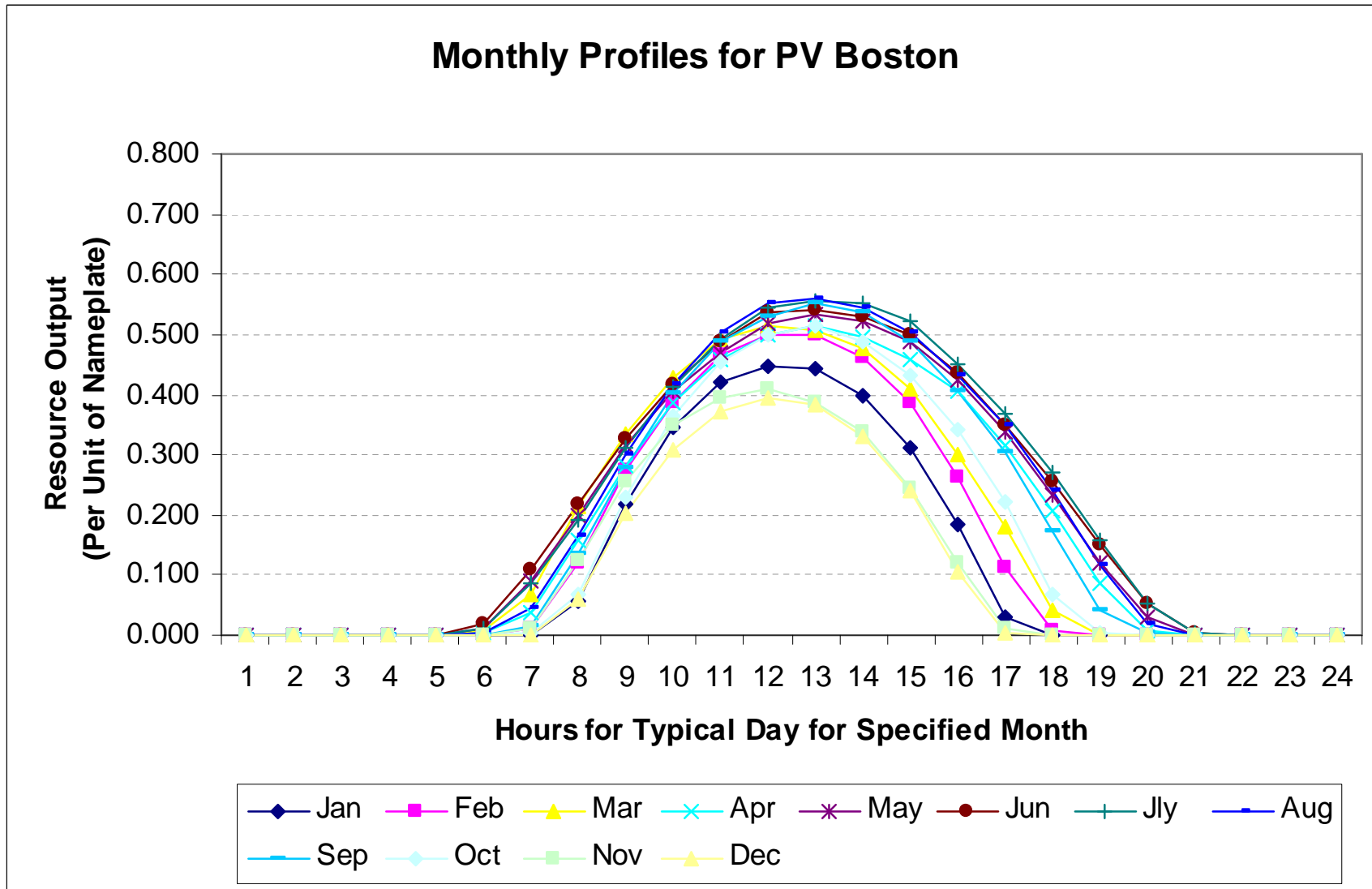
# Hartford - Photovoltaic Profile



# Hartford – Photovoltaic Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec		
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
6	0.000	0.000	0.003	0.001	0.006	0.012	0.006	0.001	0.000	0.000	0.000	0.000		
7	0.000	0.007	0.049	0.027	0.067	0.086	0.067	0.034	0.010	0.001	0.007	0.000		
8	0.039	0.094	0.181	0.133	0.166	0.181	0.165	0.142	0.103	0.050	0.093	0.041		
9	0.185	0.245	0.299	0.251	0.277	0.286	0.276	0.260	0.237	0.193	0.206	0.166		
10	0.304	0.356	0.389	0.350	0.371	0.382	0.370	0.368	0.347	0.313	0.292	0.264		
11	0.378	0.427	0.453	0.421	0.437	0.451	0.454	0.448	0.439	0.402	0.352	0.327		
12	0.419	0.471	0.477	0.476	0.487	0.499	0.512	0.499	0.493	0.464	0.369	0.349		
13	0.406	0.469	0.474	0.499	0.509	0.517	0.535	0.517	0.514	0.479	0.355	0.341		
14	0.370	0.434	0.450	0.492	0.495	0.5029	0.5252	0.5098	0.4903	0.472	0.312	0.297		
15	0.299	0.365	0.393	0.461	0.460	0.4780	0.4930	0.4768	0.4623	0.424	0.228	0.224		
16	0.180	0.260	0.297	0.397	0.398	0.4188	0.4373	0.4186	0.3893	0.339	0.118	0.109		
17	0.039	0.121	0.181	0.310	0.313	0.3330	0.3561	0.3346	0.2886	0.220	0.014	0.008		
18	0.000	0.011	0.048	0.205	0.225	0.2564	0.2648	0.2426	0.1701	0.079	0.000	0.000		
19	0.000	0.000	0.001	0.092	0.121	0.153	0.158	0.123	0.046	0.006	0.000	0.000		
20	0.000	0.000	0.000	0.010	0.032	0.061	0.057	0.024	0.003	0.000	0.000	0.000		
21	0.000	0.000	0.000	0.000	0.001	0.004	0.004	0.001	0.000	0.000	0.000	0.000		
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	0.109	0.136	0.154	0.172	0.182	0.193	0.195	0.183	0.166	0.144	0.098	0.089		
	Average Summer Capacity Value			0.3924			Annual Capacity Factor with 100 percent Mechanical Availability					0.152		
	Average Winter Capacity Value			0.0493										

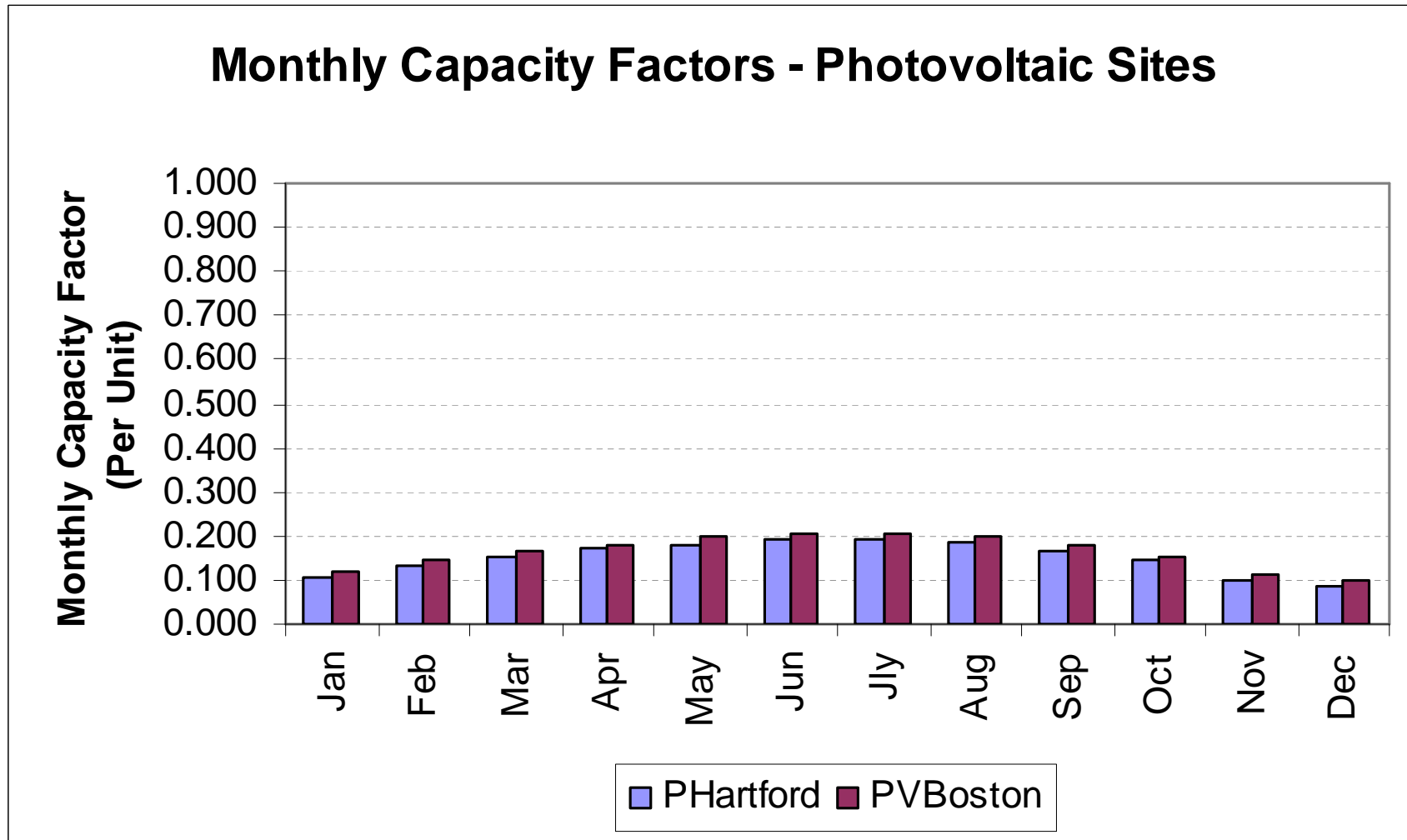
# Boston – Photovoltaic Profile



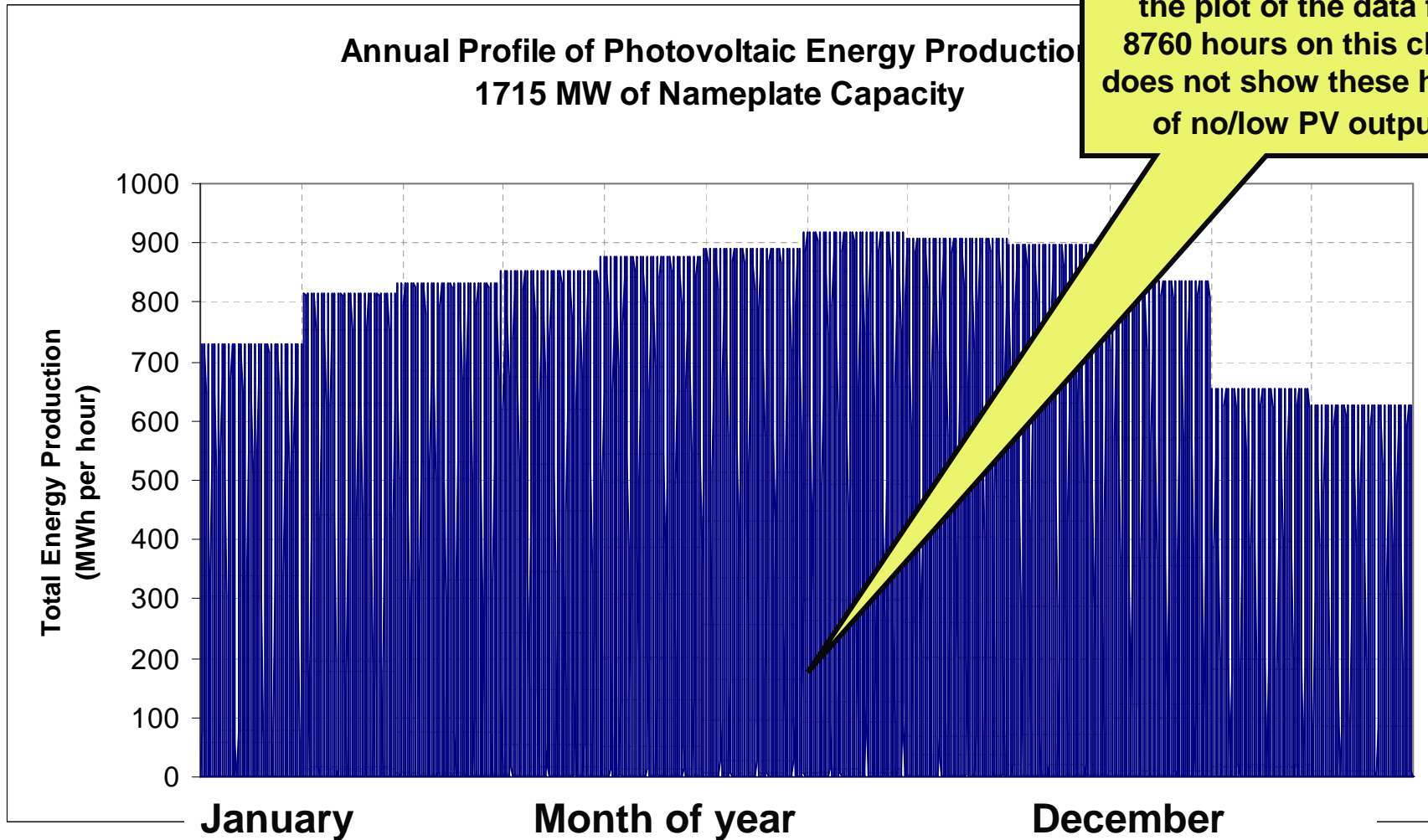
# Boston – Photovoltaic Data

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
6	0.000	0.000	0.006	0.002	0.012	0.020	0.010	0.002	0.000	0.000	0.000	0.000	
7	0.000	0.010	0.068	0.039	0.090	0.108	0.085	0.047	0.016	0.003	0.012	0.001	
8	0.057	0.119	0.213	0.158	0.200	0.217	0.192	0.167	0.134	0.069	0.125	0.059	
9	0.218	0.273	0.334	0.283	0.314	0.327	0.311	0.302	0.278	0.229	0.255	0.202	
10	0.346	0.388	0.427	0.388	0.404	0.418	0.414	0.416	0.403	0.363	0.348	0.308	
11	0.421	0.467	0.491	0.459	0.471	0.487	0.493	0.502	0.489	0.454	0.393	0.372	
12	0.448	0.499	0.513	0.501	0.517	0.535	0.543	0.553	0.531	0.500	0.411	0.396	
13	0.443	0.499	0.507	0.513	0.534	0.542	0.557	0.561	0.553	0.514	0.387	0.382	
14	0.399	0.460	0.477	0.497	0.521	0.5289	0.5505	0.5453	0.5378	0.488	0.338	0.332	
15	0.312	0.386	0.408	0.459	0.490	0.5005	0.5231	0.5042	0.4886	0.432	0.245	0.241	
16	0.183	0.265	0.302	0.404	0.423	0.4367	0.4500	0.4330	0.4040	0.342	0.119	0.107	
17	0.032	0.111	0.179	0.317	0.336	0.3506	0.3685	0.3497	0.3031	0.221	0.010	0.005	
18	0.000	0.008	0.041	0.208	0.235	0.2572	0.2709	0.2389	0.1730	0.069	0.000	0.000	
19	0.000	0.000	0.001	0.085	0.120	0.151	0.157	0.116	0.041	0.005	0.000	0.000	
20	0.000	0.000	0.000	0.008	0.028	0.054	0.054	0.020	0.002	0.000	0.000	0.000	
21	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.001	0.000	0.000	0.000	0.000	
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.119	0.145	0.165	0.180	0.196	0.206	0.208	0.198	0.181	0.154	0.110	0.100	
	Average Summer Capacity Value			0.4107			Annual Capacity Factor with 100 percent Mechanical Availability					0.164	
	Average Winter Capacity Value			0.0482									

# Monthly Capacity Factors – PV

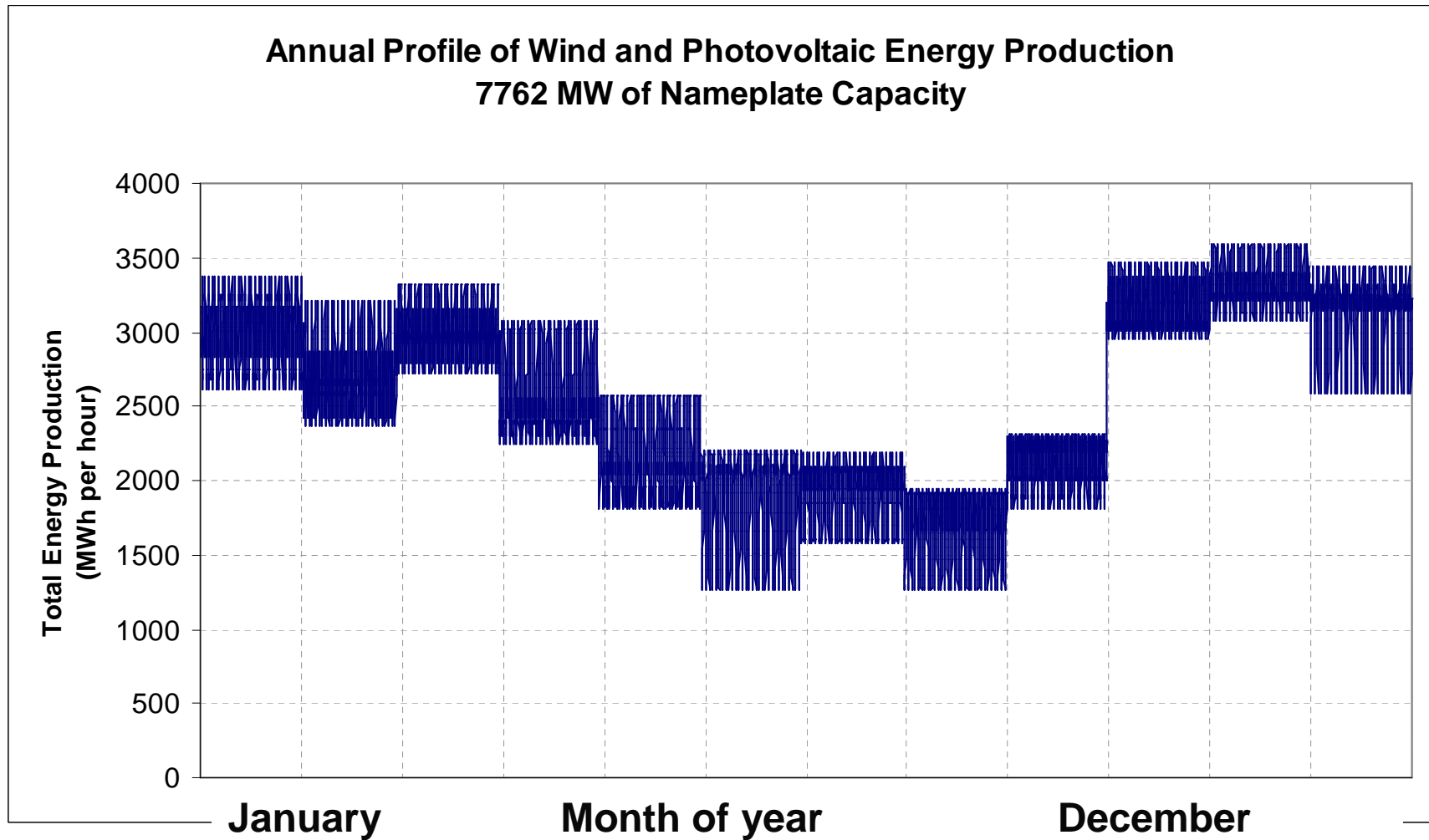


# Annual PV Generation Profile

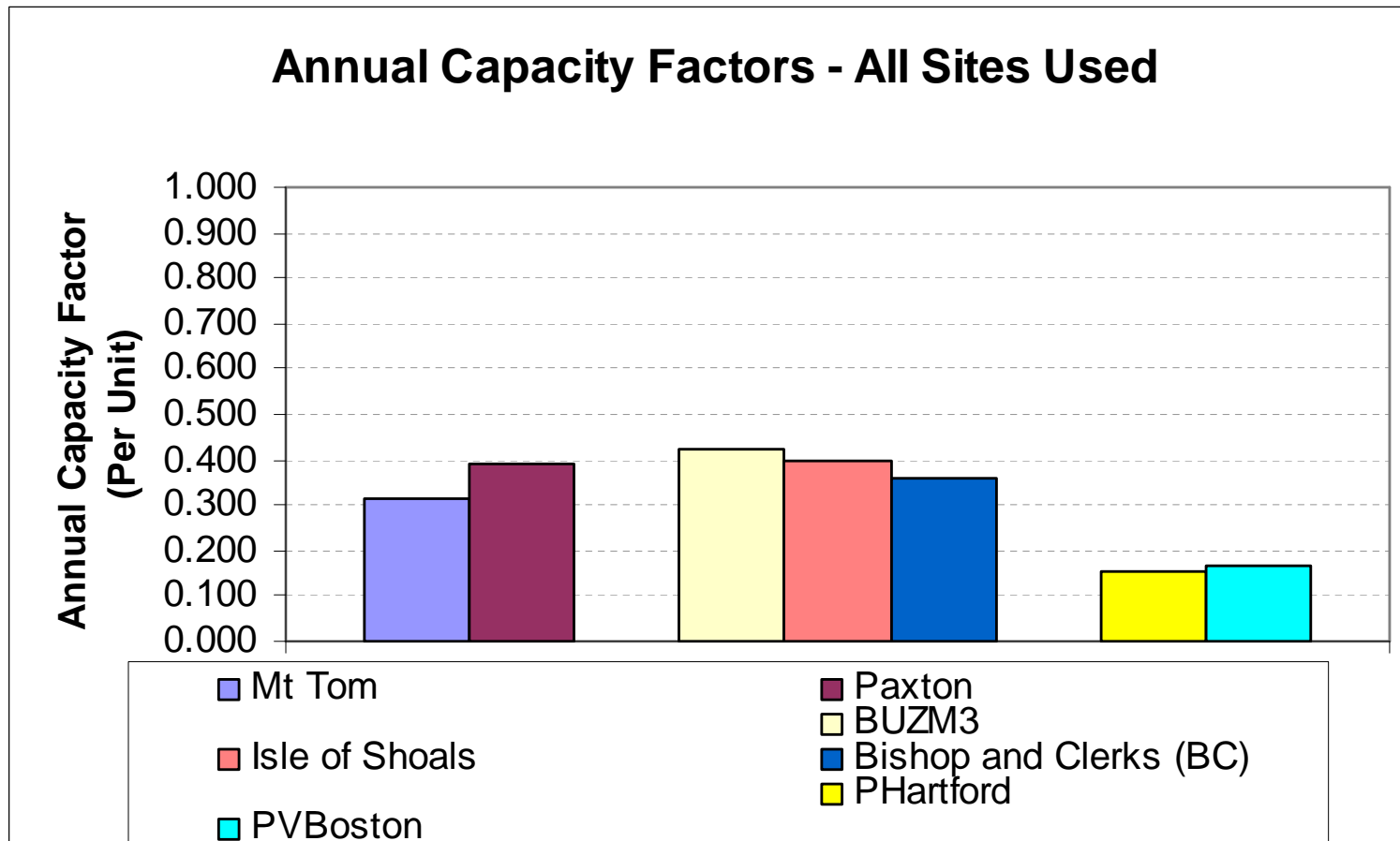


Note: Many hours have no PV energy production; but the plot of the data for 8760 hours on this chart does not show these hours of no/low PV output.

# Combined Wind and PV Profile



# Annual Capacity Factors: All Sites (Wind & PV)



# Annual Energy From Wind and PVs

