The potential benefits of natural gas storage to wind infrastructure development in Wyoming

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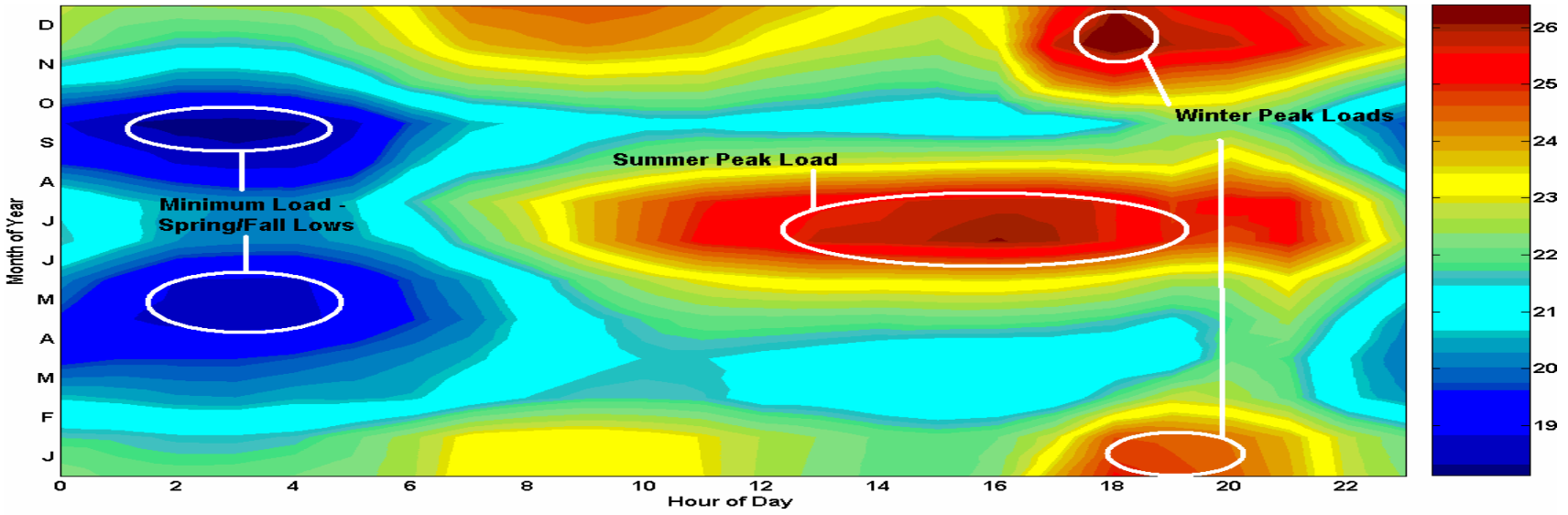
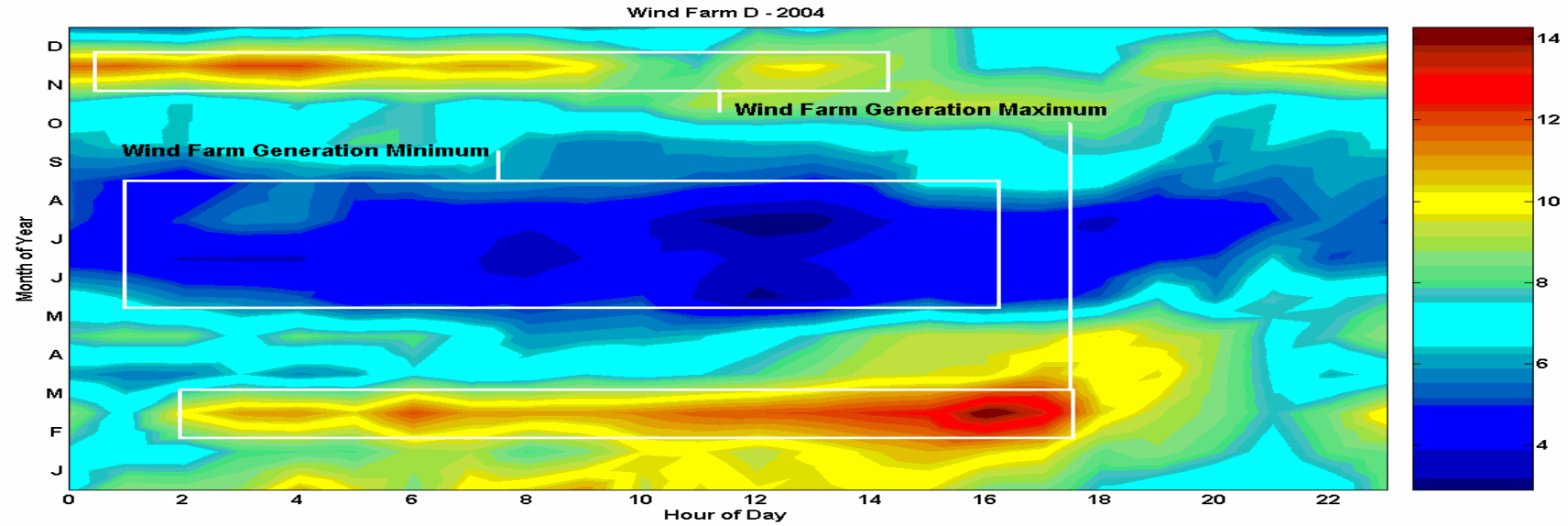
Wind supply and load demand are often mismatched





Source: Western Area Power Administration, *Wind Production Summary Overview,* October 2006.

Supply of wind is variable during the day

- Xcel Energy system for Colorado has 775 MW of wind generation capacity
- Observed maximum one hour increase in output has been 96% of nameplate capacity
- Observed maximum one hour decrease in output has been 63% of nameplate capacity
- Resources on Xcel are reasonably dispersed

Source: Xcel Energy (Public Service Company of Colorado) materials in Integrated Resource Plan filings with Colorado Public Utility Commission

Natural gas supply schedule for traditional service

- Four cut off times to schedule natural gas for delivery tomorrow
- Last chance to schedule a full load of gas for tomorrow late today
- Limited opportunity to make changes today for today
- Exception is “no notice service”

Pipelines vary on policy for variable flow

- "quantities…shall not exceed in an hour 1/24th of Scheduled Quantity"
- "Transporter and Shipper will undertake to maintain receipts and deliveries…uniform hourly basis"
- "each Party shall use reasonable efforts…reasonably uniform hourly…rates of flow
- "Shipper shall use reasonable efforts…uniform hourly…rates of flow"

Source: Language in the FERC Gas Tariff of various pipelines operating in Wyoming

Pipelines try to accommodate, but have the final say…

- "Transporter will have the right to take actions of whatever nature…to correct any imbalances…that impair…or threaten the integrity of its system"
- "Transporter may periodically have the right to take unilateral action…to preserve…operational integrity"
- "Nothing…shall limit Transporter's right to take actions of whatever nature may be required…"

Source: Language in the FERC Gas Tariff of various pipelines operating in Wyoming

Gas supply needed to replace wind drop

Wind Capacity	100 MW	200 MW	400 Mw
One Hour of lost generation	63 MW	126 MW	252 MW
Replace 1 hour with gas	650 MMBtu	1,300 MMBtu	2,600 MMBtu
Replace 8 hours with gas	5,200 MMBtu	10,500 MMBtu	21,000 MMBtu
Replace 16 hours with gas	10,400 MMBtu	21,000 MMBtu	42,000 MMBtu

Gas generation assumed at 10.45 MMBtu/MWH

No notice gas supply service

- Historical artifact of almost every system
- Legacy storage used
- Usually a “bundled” service
- Sold out as a “bundled” service on every existing system
- New facilities have and can be built – storage is key

Gas supply scenario with storage

- Typical storage facility can withdraw 2x injection
- Buy gas for each day equal to 1/3rd of demand
- If wind blows – inject to storage
- If wind dies – withdraw from storage to augment gas that was purchased
- How much storage to buy depends on field characteristics

Simple example

- If no wind, assume daily gas demand 30,000 MMBtu for the power plant
- Buy 10,000 MMBtu every day
- If wind does blow hard – inject 10,000 MMBtu
- If wind doesn't blow at all – withdraw 20,000 MMBtu and have 30,000 MMBtu of total supply

Other considerations

- Gas generation relative to wind farm location flexible
- Gas generation and storage should be on common pipeline
- Connection to large line better
- Gas generation at or upstream of storage and other loads is best
- Could lower unit cost of power lines

WPA activities

- Provide forum for storage projects
- Support projects before FERC
- Share information with WIA
- Generate the discussion