BONNEVILLE
POWER ADMINISTRATION

Generation Inputs Workshop

25 June 2014

BPA's Centralized Wind Power Forecasting Initiative

Scott Winner

BPA's Centralized Wind Power Forecasting Initiative

- Project Goals
  - **Situational Awareness**
    - Displays for real-time to communicate wind generation magnitude, ramps and uncertainty
  - **Load / Resource Balancing**
    - Integrate forecasts into load/resource modeling
  - **Wind Power Scheduling**
    - Provide project specific forecasts to customers to aid in their scheduling

BPA's Centralized Wind Power Forecasting Initiative

- BPA-owned met tower network, 20 towers
  - Publicly posted data
    - Includes historical data back to 1976
- BPA external vendors
  - 2 external vendors
    - Energy & Meteo Systems and WEProg
- BPA post processing
  - The Super Forecast methodology
    - BPA's solution for blending the two vendor forecasts

Super Forecast Methodology (SPF)

- When you have two forecasts, which do you use?
  - A: the one that is the best
- What is best?
  - A: the forecast that has the smallest forecast error
- Evaluation metric: Forecast Error (FE)
  - FE = ABS(hourly forecast – hourly generation)

	Forecast	Generation	ABS(error)	best
Vendor A	70	72	2	BEST!
Vendor B	60	72	12	
average	65	72	7	

← Use this one

7 Days of Vendor Forecast Error

- What is best? (refined)
  - Not just lowest forecast error,
  - but which vendor most frequently has the lowest forecast error?
- Evaluation period, past seven days
  - Over the past seven days (n=168 hours), which vendor had the lowest forecast error more frequently?

	FE n=1	FE n=2	FE n=3	FE n=4	FE n=5	FE n=168
Vendor A	2	7	12	17	23	41
Vendor B	12	13	12	11	9	7
average	7	10	12	14	16	24

SPF Ranking

- The metric is **most frequent** lowest error
  - Win, place, show ranking

	FE n=1	FE n=2	FE n=3	FE n=4	FE n=5	FE n=168
Vendor A	2	7	12	17	23	41
Vendor B	12	13	12	11	9	7
average	7	10	12	14	16	24

	rank n=1	rank n=2	rank n=3	rank n=4	rank n=5	rank n=168
Vendor A	win	win	win tie	show	show	show
Vendor B	show	show	win tie	win	win	win
average	place	place	win tie	place	place	place

SPF Scoring

- Best is the forecast with the most wins
  - win = 1

	rank n=1	rank n=2	rank n=3	rank n=4	rank n=5	rank n=168
Vendor A	win	win	win tie	show	show	show
Vendor B	show	show	win tie	win	win	win
average	place	place	win tie	place	place	place

	rank n=1	rank n=2	rank n=3	rank n=4	rank n=5	rank n=168	wins
Vendor A	1	1	1	0	0	0	61
Vendor B	0	0	1	1	1	1	90
average	0	0	1	0	0	0	19

← Use this one

SPF Scope

- Best forecast: Vendor B!
  - Moving forward we will use vendor B
- This analysis is done
  - Every hour
    - Each hour we drop an hour and add an hour
  - For each wind plant (n=31)
  - For each hour of the forecast (n=168)
    - Vendors provide a seven day forecast
    - Each hour of the forecast is evaluated; FH1, FH2, FH3…

SPF Matrix

- The methodology produces a matrix
  - This analysis happens between xx:01 and xx:10

Winners	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
VSW	B	B	B	B	A	A	A	A	A
STL	B	B	B	A	A	A	A	A	A
KLN	AVG	AVG	A	A	A	B	B	B	B
CWP	A	B	B	B	B	B	B	B	B
KN2	B	B	B	B	B	B	B	B	B
HRW	B	AVG	AVG	AVG	AVG	AVG	B	B	B
BHW	A	A	A	A	A	B	B	B	B

SPF Sorting

- At xx:10, the new wind power forecasts arrive

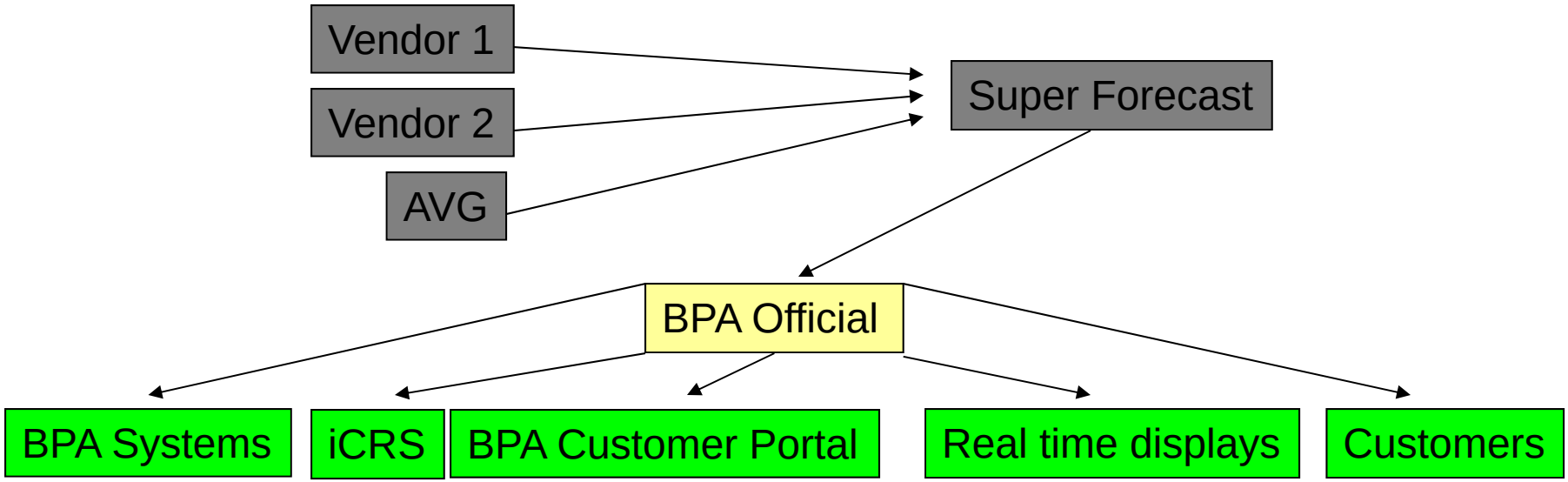
Winners	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
VSW	B	B	B	B	A	A	A	A	A

VSW forecasts	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
A	7	9	22	20	20	17	18	22	0
B	9	13	20	22	22	21	20	18	2
AVG	8	11	21	21	21	19	19	20	1

SPF	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
VSW	9 (B)	13 (B)	20 (B)	22 (B)	20 (A)	17 (A)	18 (A)	22 (A)	0 (A)

SPF Publishing

- The SPF output is then published to BPA systems



SPF Reliability Function

- If a vendor fails to deliver, the SPF move to Place

Winners	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
VSW	B	B	B	B	A	A	A	A	A

VSW forecasts	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
A	null	null	null	null	null	null	null	null	null
B	9	13	20	22	22	21	20	18	2
AVG	9	13	20	22	22	21	20	18	2

SPF	FH1	FH2	FH3	FH4	FH5	FH6	FH7	FH8	FH168
VSW	9 (B)	13 (B)	20 (B)	22 (B)	22 (B)	21 (B)	20 (B)	18 (B)	2 (B)

SPF Default Vendor

- In the event of a ranking tie, or a ranking applications error, the SPF will publish to a default vendor

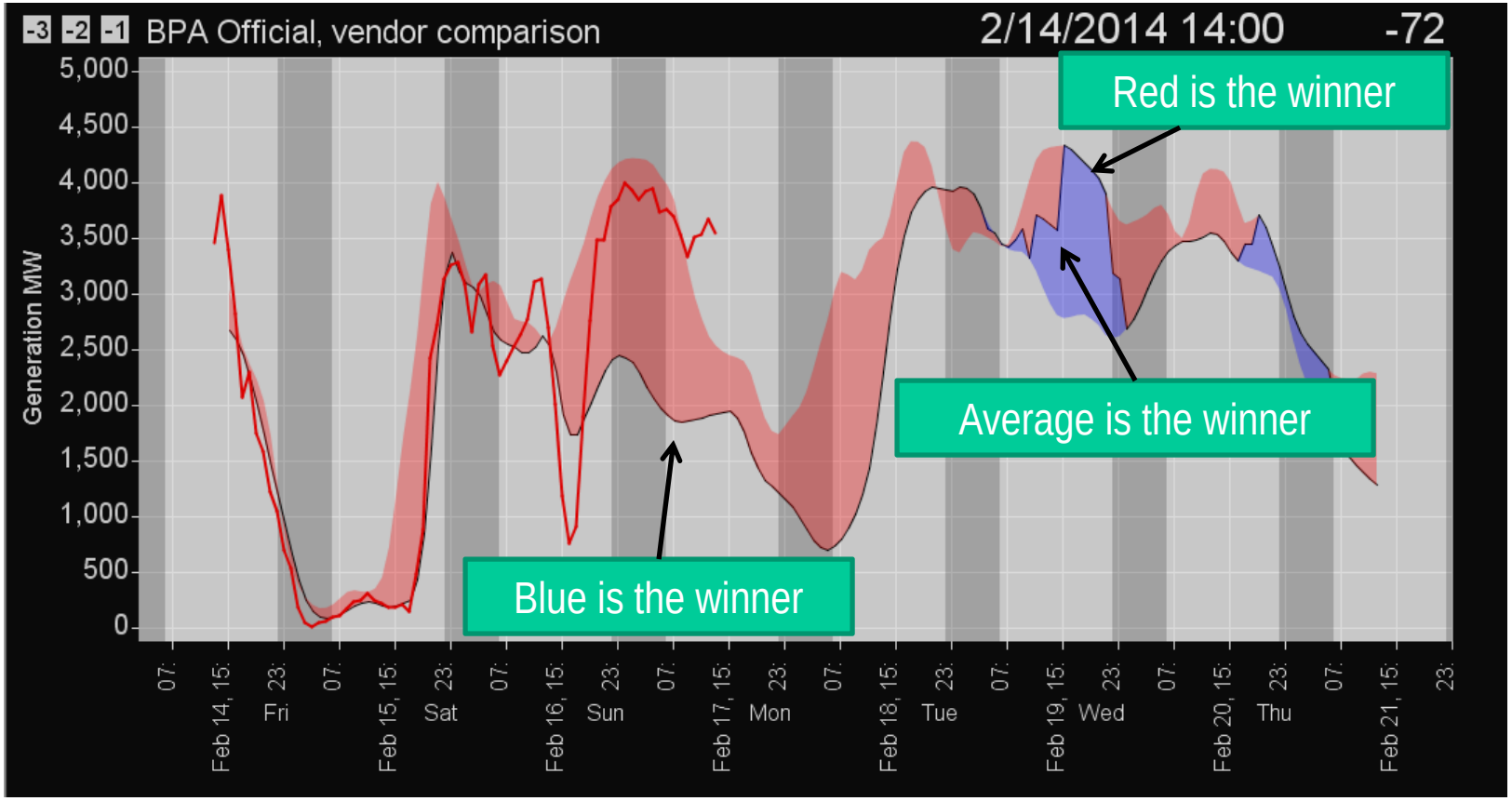
	rank n=1	rank n=2	rank n=3	rank n=4	rank n=5	rank n=168	wins
Vendor A	1	1	1	0	0	0	75
Vendor B	0	0	1	1	1	1	75
average	0	0	1	0	0	0	20

← Use this one

	rank n=1	rank n=2	rank n=3	rank n=4	rank n=5	rank n=168	wins
Vendor A	null	null	null	null	null	null	null
Vendor B	null	null	null	null	null	null	null
average	null	null	null	null	null	null	null

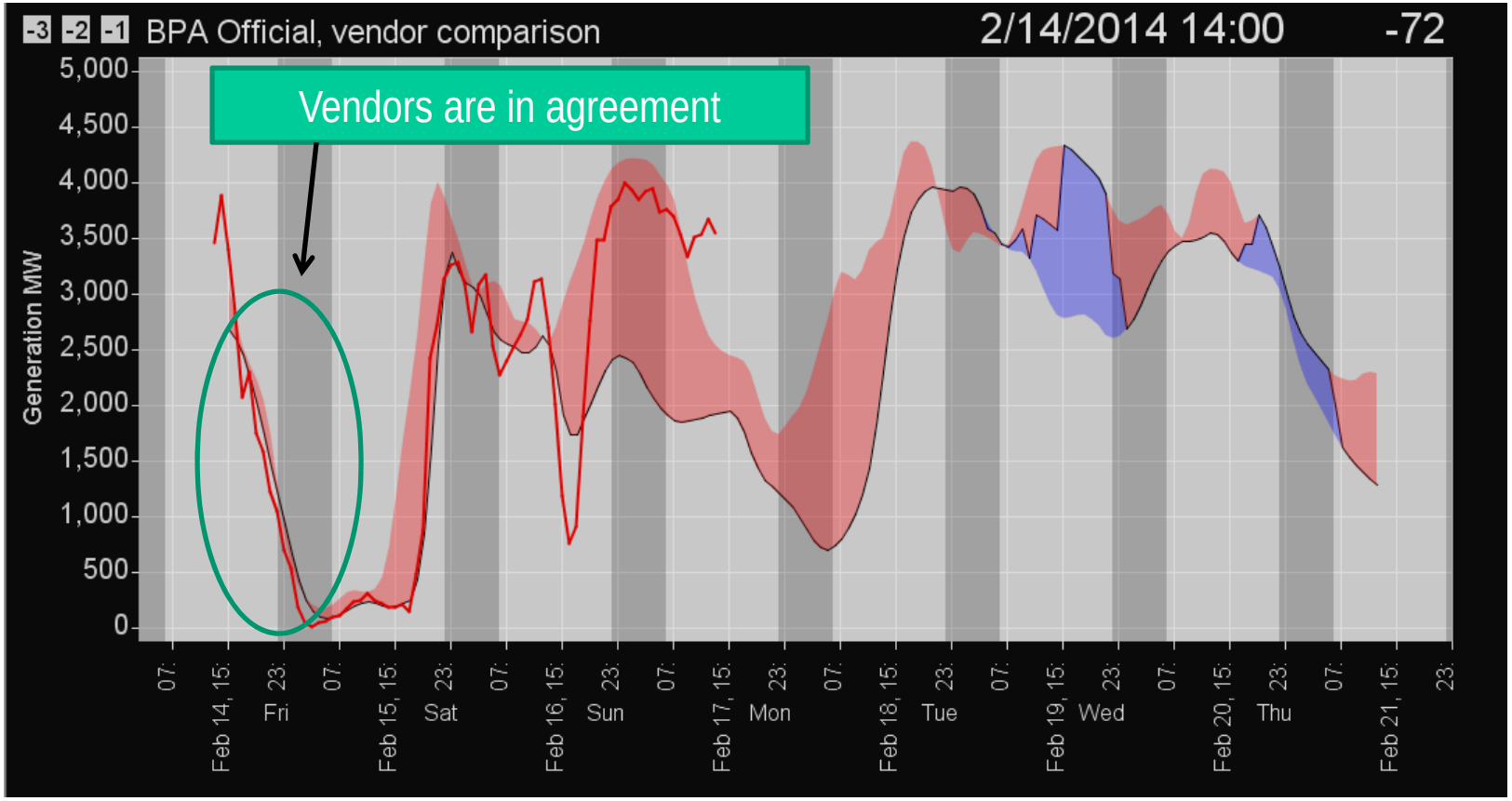
← Use this one

SPF performance



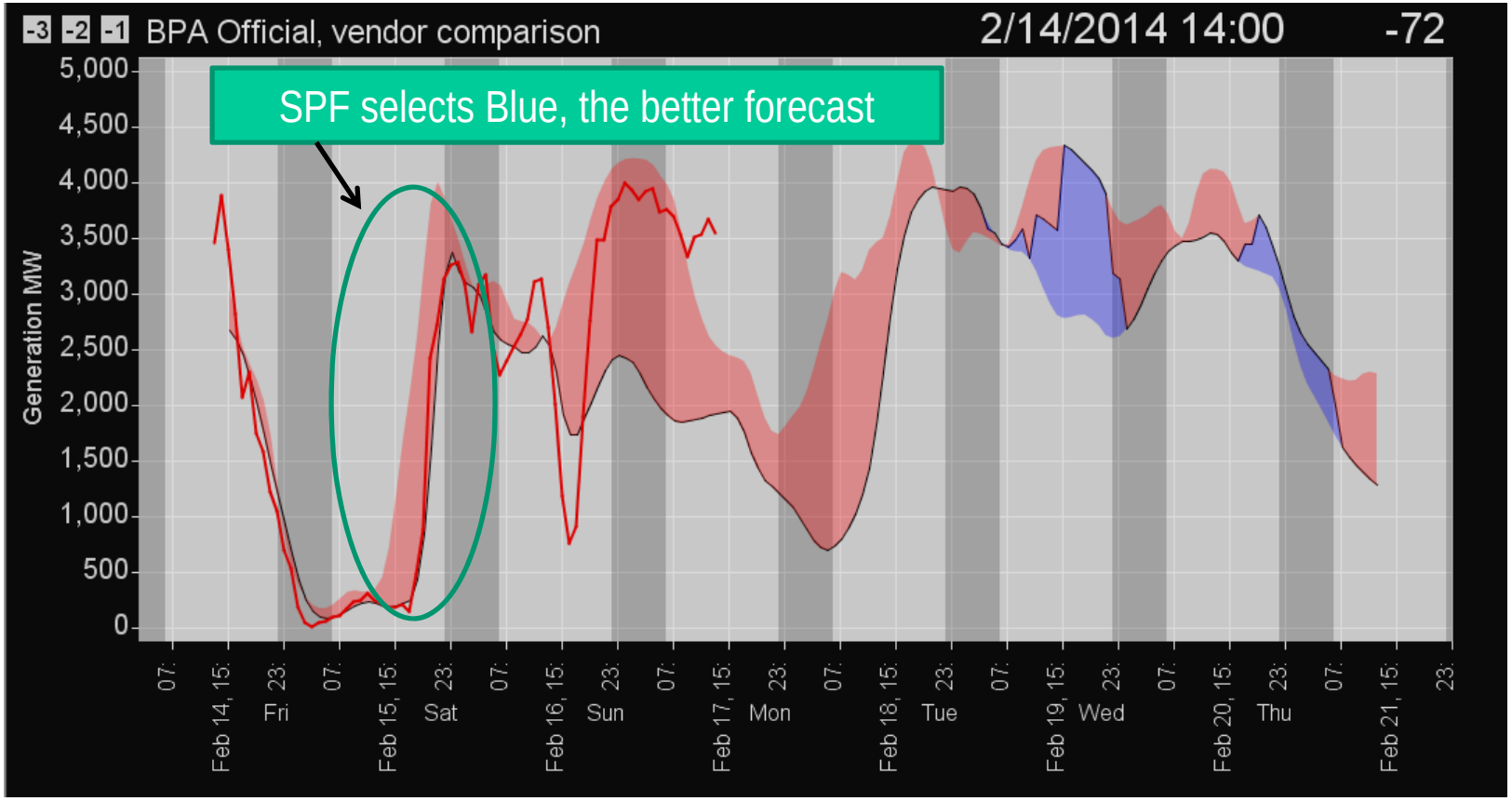
Black line is SPF, Blue is vendor A, Red is vendor B
Red line is actual fleet level generation

SPF performance



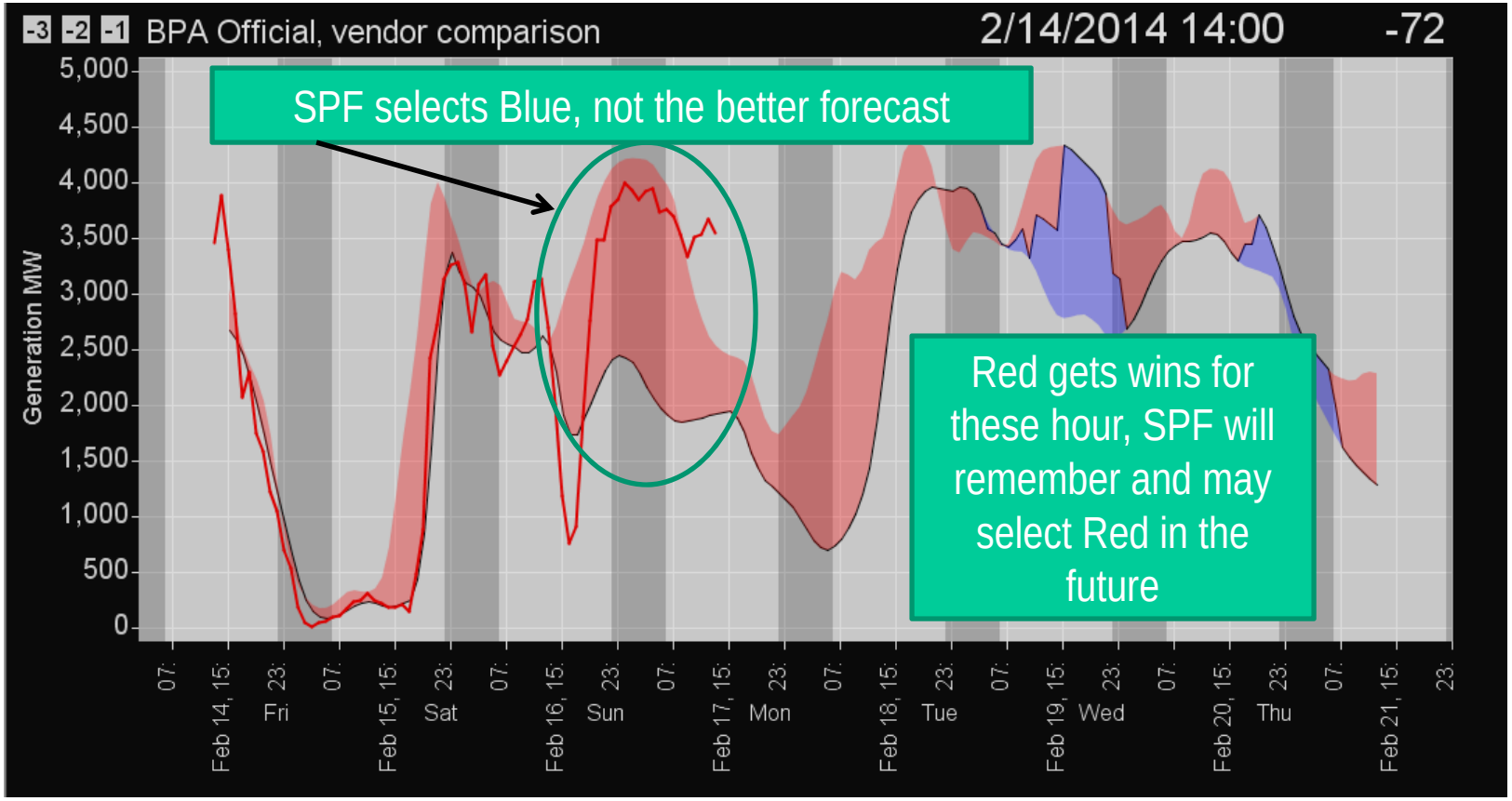
Black line is SPF, Blue is vendor A, Red is vendor B
Red line is actual fleet level generation

SPF performance



Black line is SPF, Blue is vendor A, Red is vendor B
Red line is actual fleet level generation

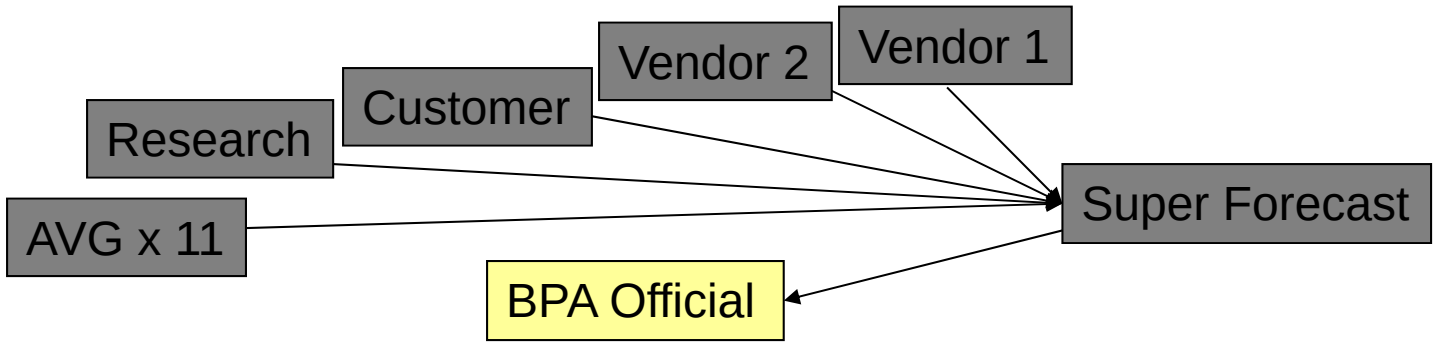
SPF performance



Black line is SPF, Blue is vendor A, Red is vendor B
Red line is actual balancing reserves deployed

Integrating Customer Forecasts

- The SPF is being redesigned to accommodate customer-supplied wind power forecast
- The customer forecast will be evaluated the same as vendor forecasts
  - If it is **best** it will be published to BPA Official
- The customer forecast can be as short as 1 hour or up to 72 hours, the SPF is resilient



Useful Links

- Posting of a historical wind power forecast in aggregate
  - http://www.bpa.gov/Projects/Initiatives/Wind/Pages/Wind-Power-Forecasting-Data.aspx
- BPA-owned met tower network
  - Downloadable data
    - http://transmission.bpa.gov/Business/Operations/Wind/MetData.aspx
  - Data visualization display
    - www.bpa.gov/go/windsocks