AWEA WindPower
Las Vegas

2014-05-07

Yield and Uncertainty Validation

For Pre- and Post-Construction
Wind Resource Assessment

WSP

Setting the Stage

- Historically, project yields haven't met expectations

  bias of ≅ 8-10%

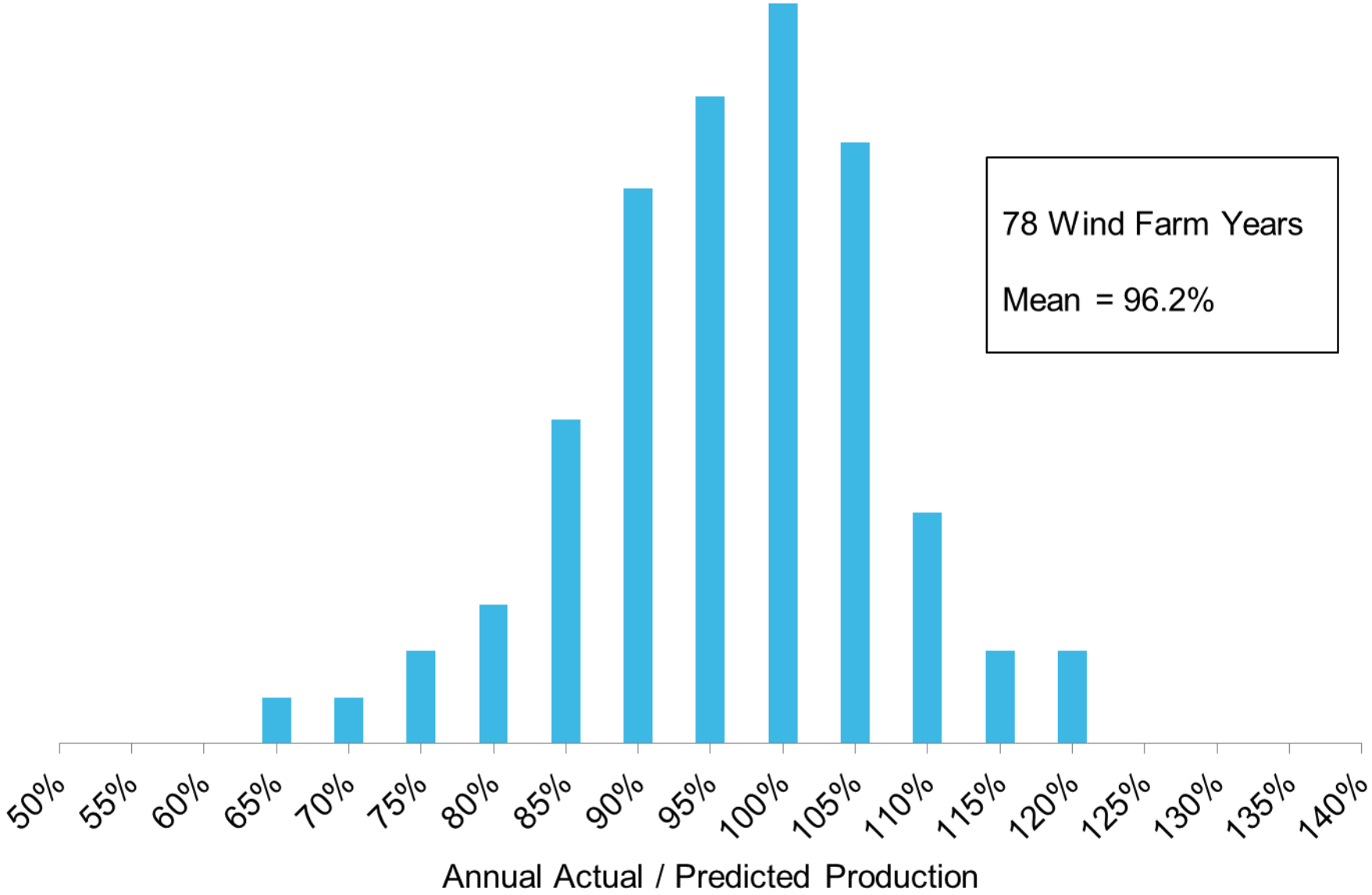
- Recent studies give reason to believe that the industry is getting better:

  bias ≅ 0-2%

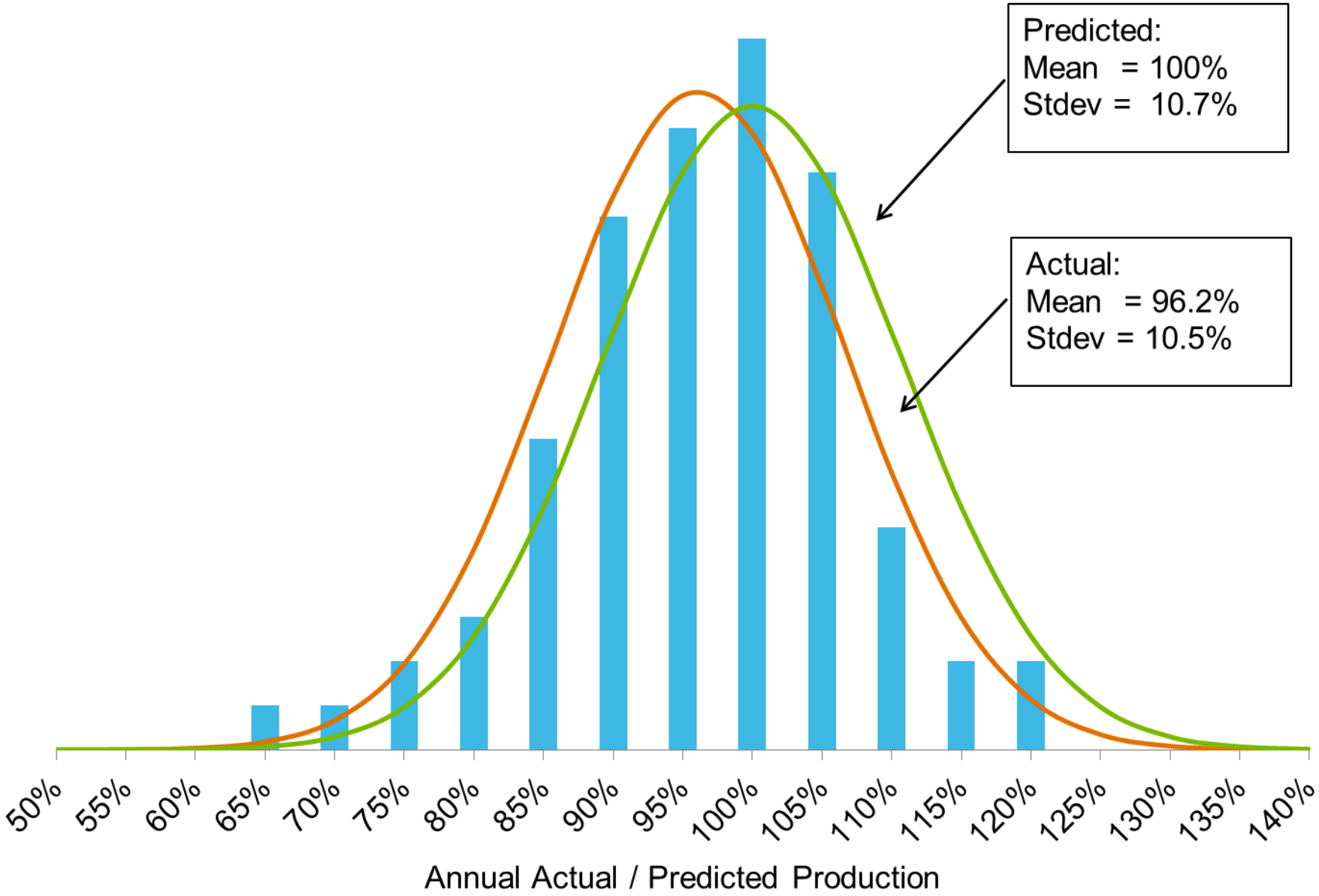
WSP Validation Results

- Compare pre-construction P50 to actual yields
- Actual production is unadjusted (includes curtailment)

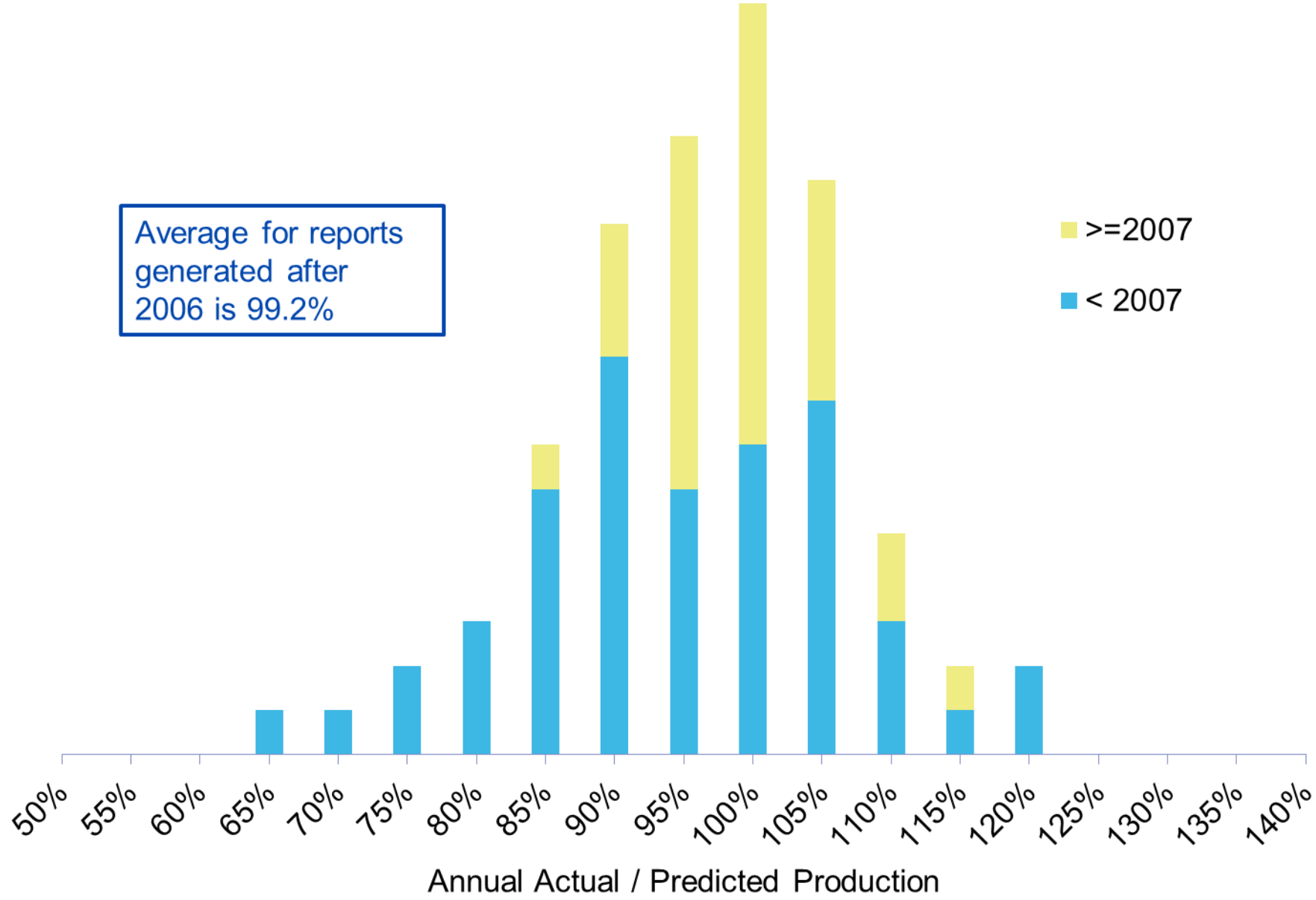
Pre-Construction Validation Results



Pre-Construction Validation Results



Pre-Construction Validation Results



Notable Challenges and Sources of Improvement

- Wind flow modeling
- Wake modeling
- Turbine performance
- Availability

Production Assessment

- **Increasingly, assessments performed based on facility production data**
- **Several sources of uncertainty go away (or diminish significantly) once production data is available:**
  - Wind flow modeling
  - Wake losses
  - Turbine performance
  - Availability

Production Assessment

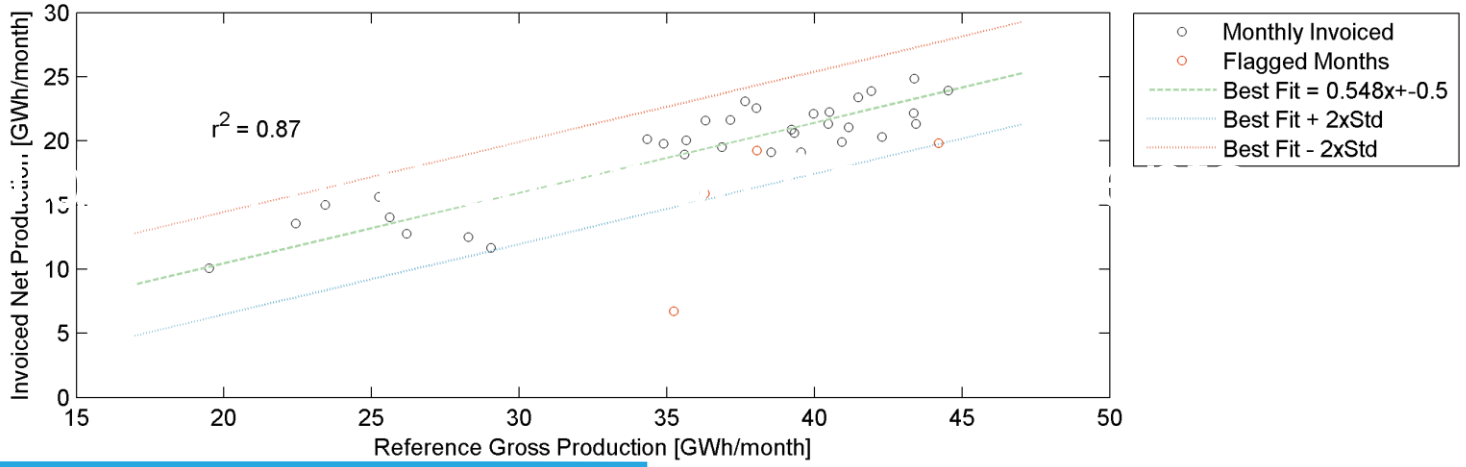
- Do production assessments validate?
- Is a significant decrease in uncertainty warranted (relative to pre-cons)?
- Can the validation of production assessments help us with pre-construction resource assessment?
- What does “representative data” mean in the context of production assessments?

Validation of Production Assessments

- Validate projects assessed using production data
- For WSP projects:
  Actual = 99.8% of P50
  σ_{actual} = 5.7%
  $\sigma_{predicted}$ = 9.2%
  n = 12
- Need to look at more data…

Validation of Production Assessments

- **Use monthly production data from EIA**
- **Generate long-term predictions for each project using reanalysis data**
- **Base prediction on 1 year of data, validate with remainder**
- **Exclude commissioning period**
- **Exclude projects with changes in nameplate capacity**
- **Exclude projects of less than 10 MW**

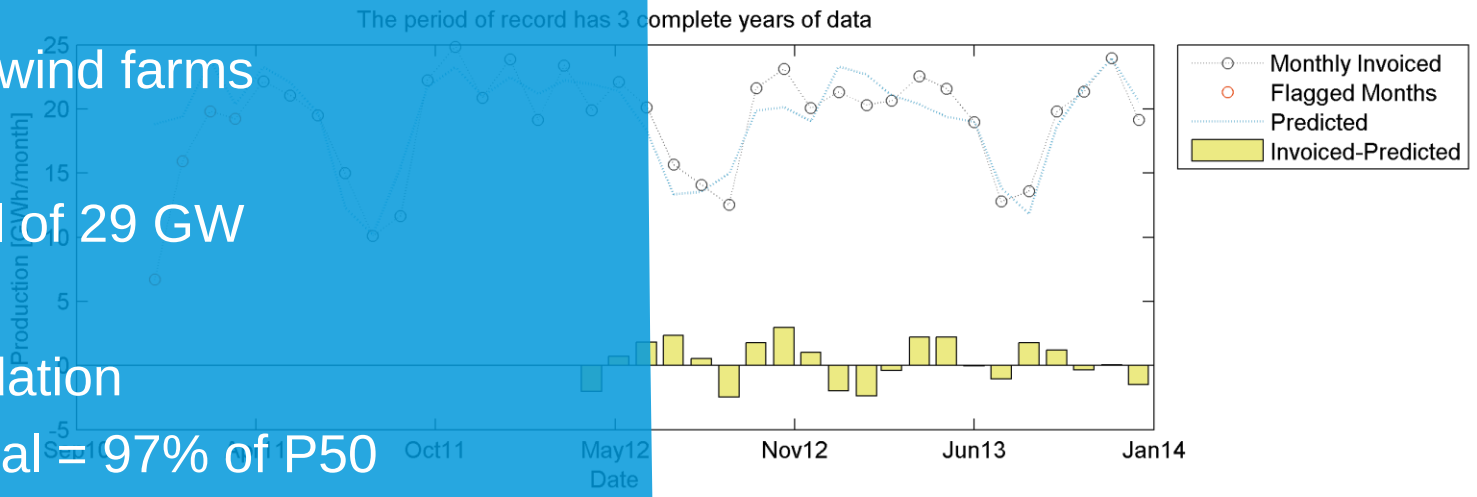


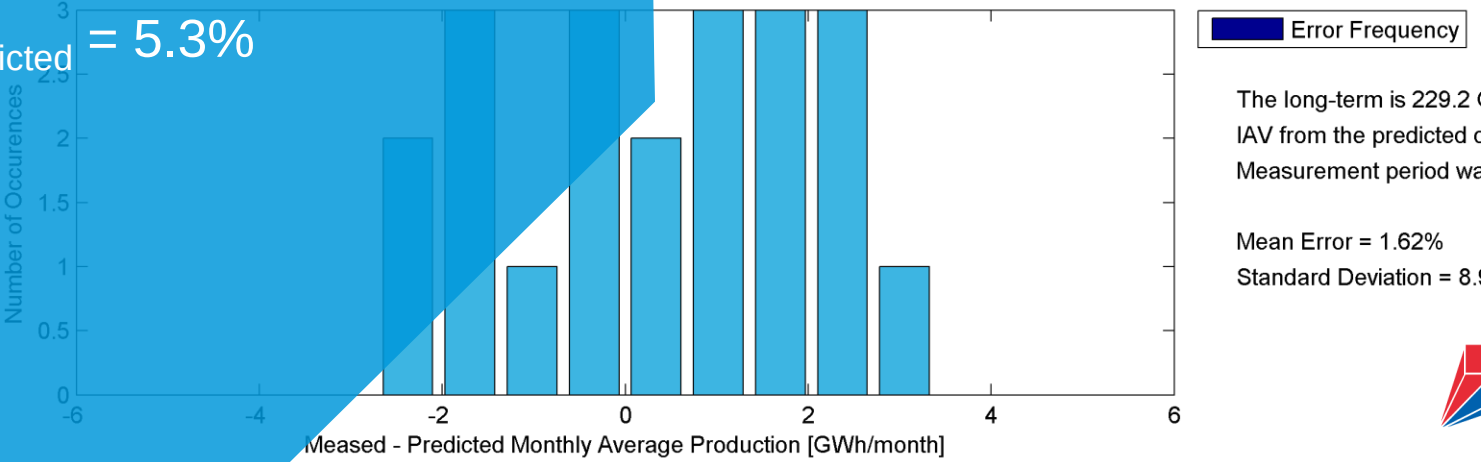
- 312 wind farms
- Total of 29 GW
- Validation

  Actual = 97% of P50

  σ_{actual} = 9.8%

  $\sigma_{predicted}$ = 5.3%



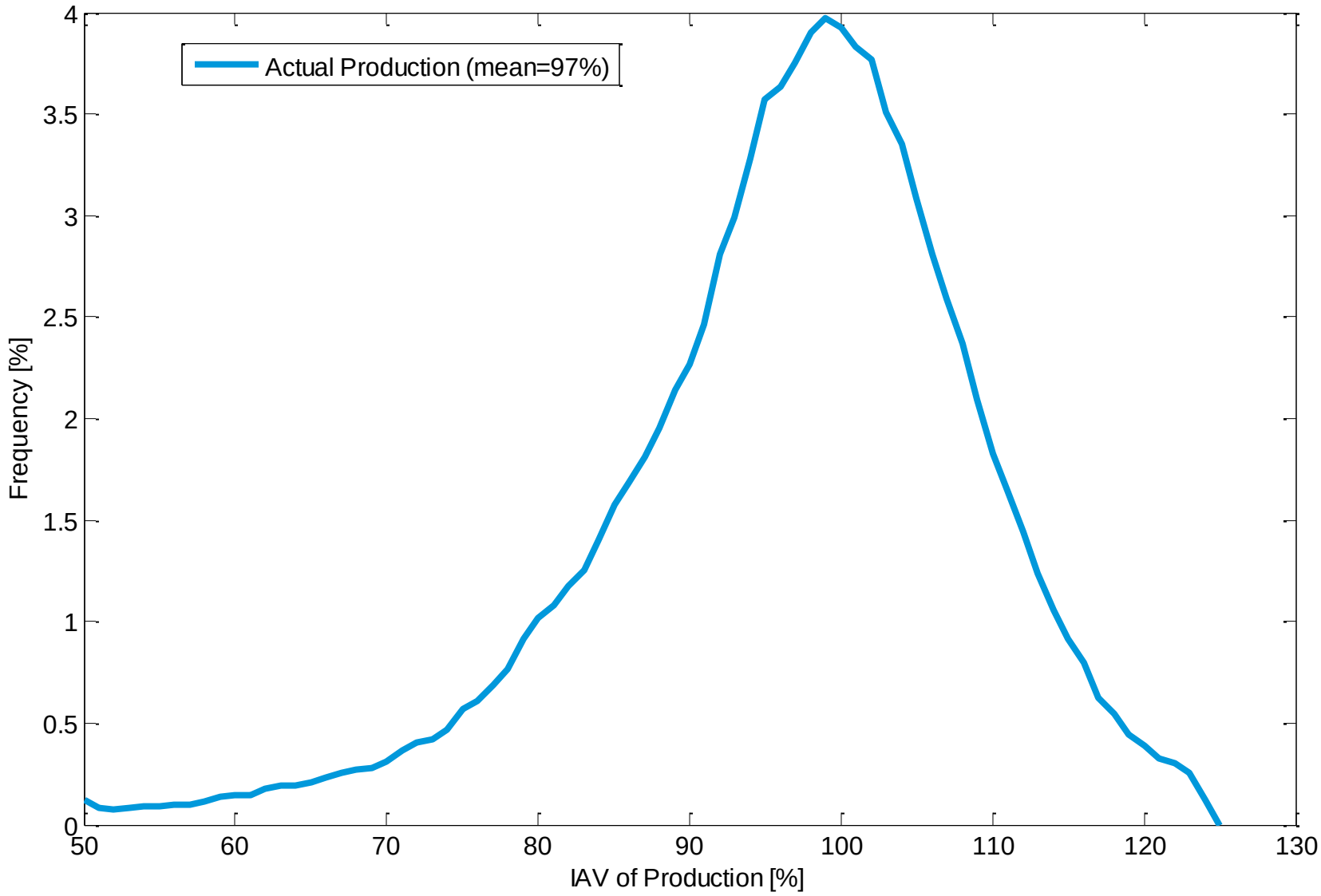


The long-term is 229.2 GWh (43.6%)
IAV from the predicted data is 5.87%
Measurement period was 2 years

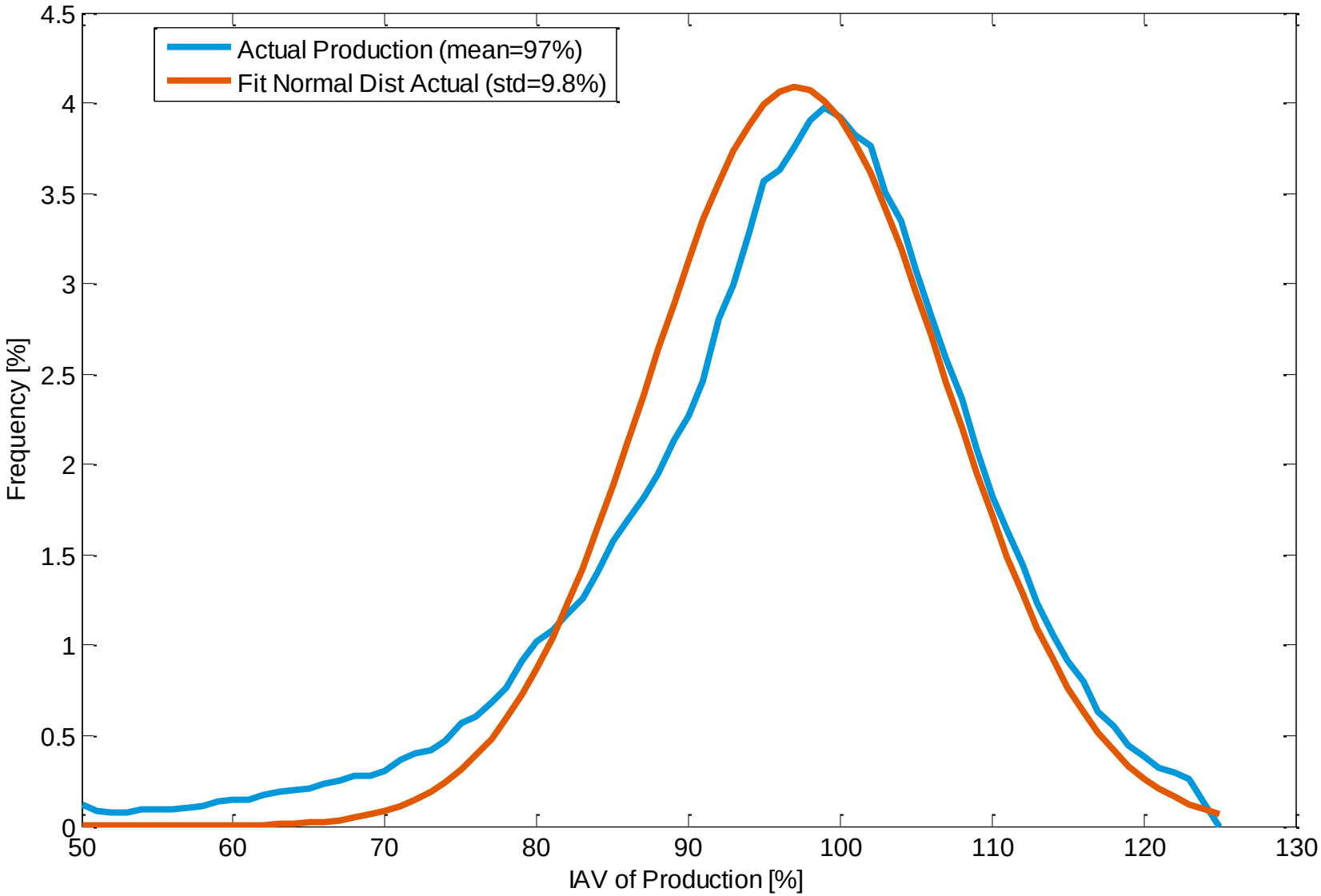
Mean Error = 1.62%
Standard Deviation = 8.94%

WSP

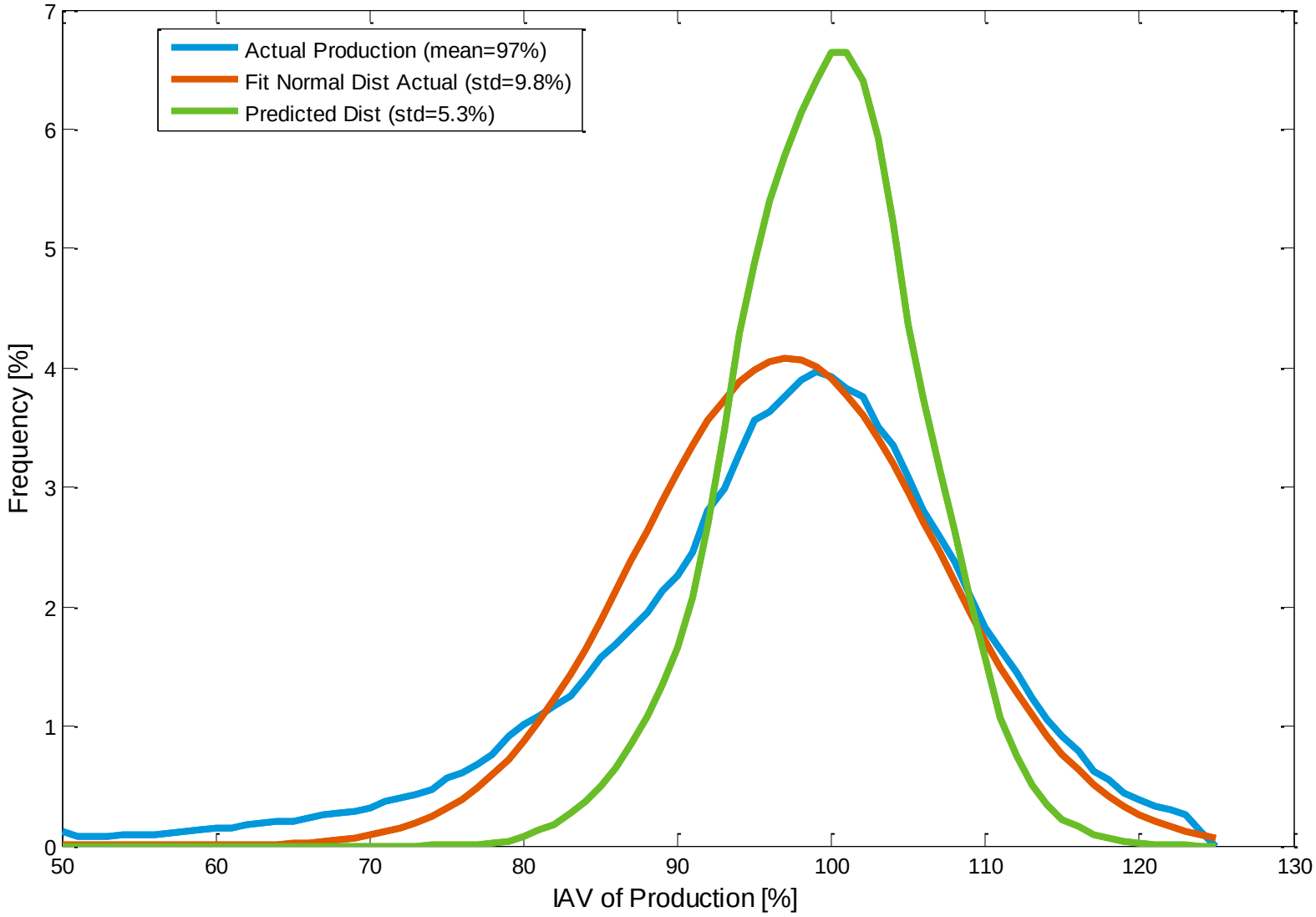
Validation of Production Assessments



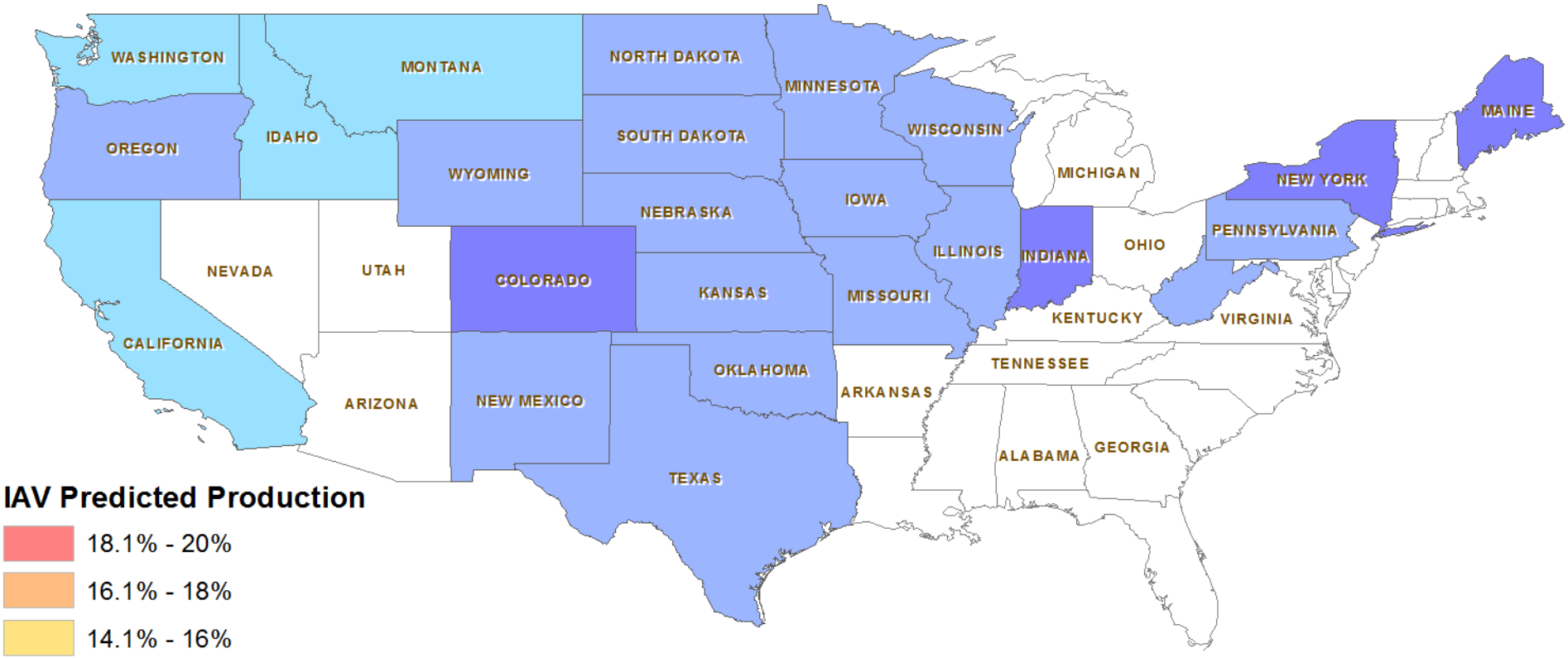
Validation of Production Assessments



Validation of Production Assessments



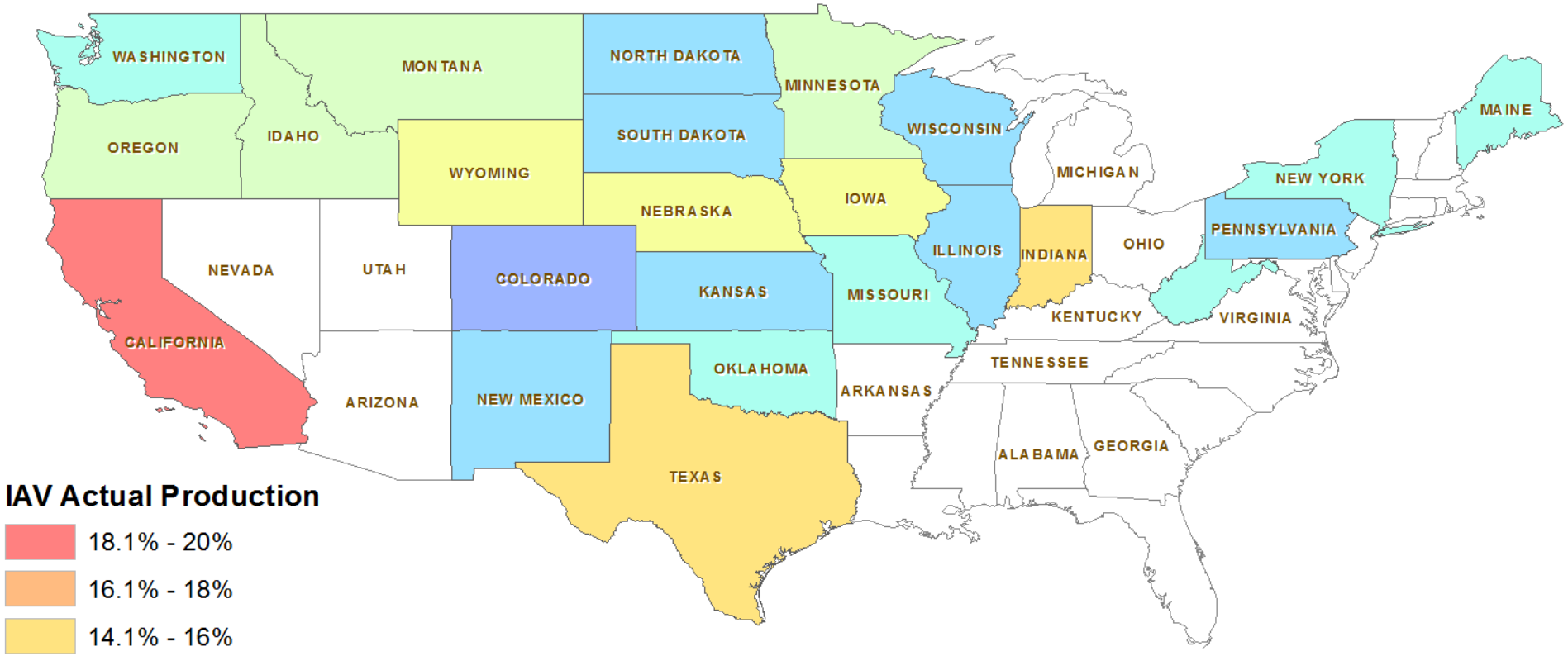
Inter-Annual Variability of the Resource



IAV Predicted Production

- 18.1% - 20%
- 16.1% - 18%
- 14.1% - 16%
- 12.1% - 14%
- 10.1% - 12%
- 8.1% - 10%
- 6.1% - 8%
- 4.1% - 6%
- 3.5% - 4%

Inter-Annual Variability of Actual Production



IAV Actual Production

- 18.1% - 20%
- 16.1% - 18%
- 14.1% - 16%
- 12.1% - 14%
- 10.1% - 12%
- 8.1% - 10%
- 6.1% - 8%
- 4.1% - 6%
- 3.5% - 4%

Observations

- **Do production assessments validate?**
  - For WSP portfolio, so far they have
  - Using a coarse monthly methodology, we see a bias…
- **Is a significant decrease in uncertainty warranted (relative to pre-cons)?**
  - Yes, but…
- **What does "representative data" mean in the context of production assessments?**
  - Production data either needs to have representative performance "baked in"
  - …Or need to back out observed losses and apply those that are representative (availability, turbine performance, curtailment, wake…)
  - More easily accomplished when the production data has good temporal resolution and accurate / clear flags

Observations

→ **Can the validation of production assessments help us with pre-construction resource assessment?**

- Significant inter-annual variability not attributable to the resource
- Wind resource assessment reports often assign around 4% to IAV of wind speed
- Results imply that for many projects this may be a bit high (assuming a conversion factor of around 1.5x to 2.0x for wind speed)
- However, this may help compensate for the underestimation of the IAV of actual production:
  - Curtailment
  - Long-term trends e.g. decreasing production due to wake effects of neighboring projects
  - IAV of icing losses

WSP

Closing Remarks

- Ultimately WRA results are an important input into estimates of profitability
- This poses a challenge for validation of results based on production since projects may be compensated by other means e.g.
  - turbine performance
  - curtailment