Study Committee C1

Power System Development and Economics

Paper 10221_2022

Risk Modelling in the Decarbonization of Electric Systems

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Motivation

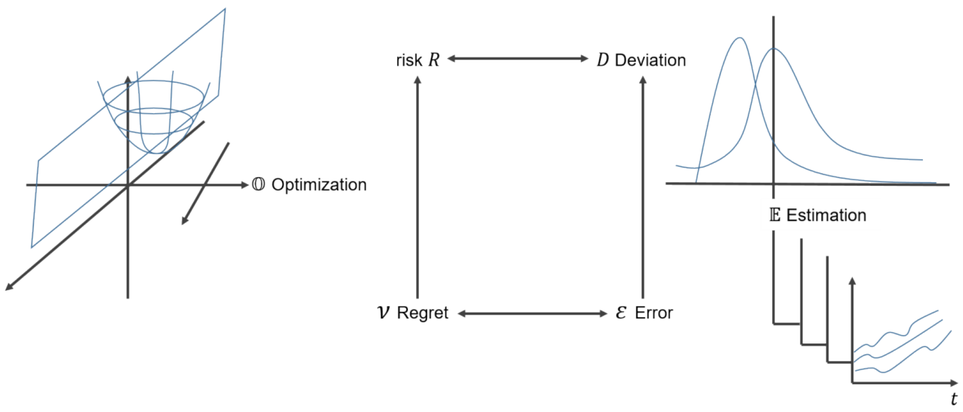
- Information failures regarding assets. Information either **imperfect** or **asymmetric**
- **Missing mechanisms to manage risk** (e.g., lack of protocols) Resulting from information failures.

Tighter uncertainty bands, better understanding of future risk

Better dispatch decisions by operators & other market participants

Better Risk Management

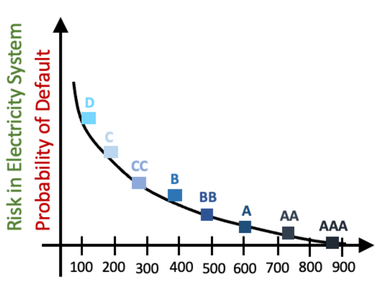
Methodological Approach

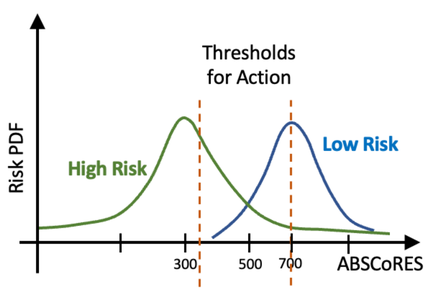


- Risk Bureau can enable financial products for electricity markets to trade and manage asset and system risk.
- Summarize multidimensional data to capture probabilistic risk profile

Objects of investigation

Our project will introduce an independent third-party assessment of risk for each asset based on historical and scenarios data. As, for example, done by scoring and rating systems used in banking and finance to produce credit scores and risk grades.





Threshold treatment according to score and planning

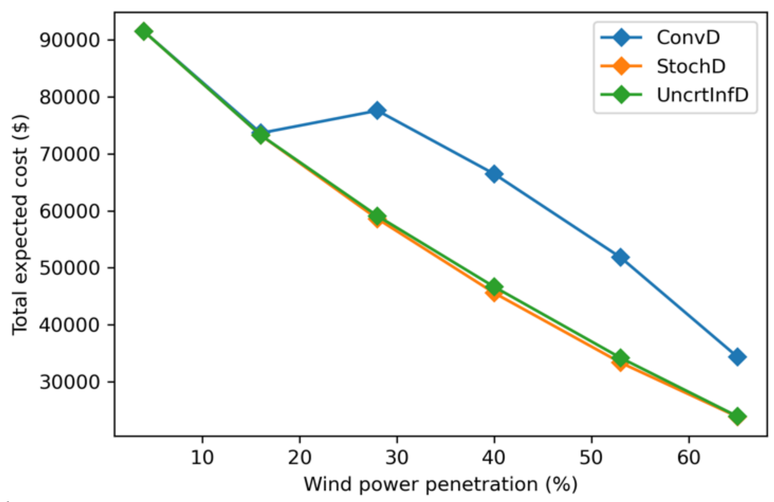
Experimental setup & test results

- Start with synthetic or digital twin of pilot partner system to calculate scores
- Identify geographic subregion or other subset of assets, A, perform counterfactual and `What if' analysis
- Provide ABSCoRES to stakeholders and market participants, work together on use of `What if' analysis

1. ConvD, a conventional deterministic Security-Constrained Optimal Power Flow (SCOPF)
2. StochD, a stochastic SCOPF
3. UncrtInfD, an uncertainty-informed deterministic SCOPF

Discussion

- As wind power generation increases, expected cost of the uncertainty informed dispatch resembles the cost of the stochastic dispatch.
- Wind generation higher than 15 percent, expected operating costs for conventional dispatch, ConvD, substantially higher than the stochastic dispatch or the uncertainty informed dispatch methodologies test results



Conclusion

- Explanation of the factors driving the sample scores are easy to explain to stakeholders
- Trade-off between transparency and the potential for manipulation in some of the attributes of the score

VAR ID	VAR NAME	Description	Information Value
7	lmp lag 2	Lagged twice Locational marginal price	0.009725
6	lmp lag 1	Lagged Locational marginal price	0.015734
5	lmp	Locational marginal price	0.021412
0	bus id	Injection point	0.108324
1	cf	Capacity facotr	0.109980
14	ramp pct lag 2	Lagged twice ramp percentage capacity	0.131317
12	ramp pct	Lagged ramp percentage capacity	0.143055
13	ramp pct lag 1	Ramp percentage capacity	0.156158
9	p max	Rated Capacity	0.259456
11	pg	Dispatch	0.360878
8	nominal ramp	Rated ramp capability	0.795492
10	p min	Minimum Dispatch	1.052294
3	deviation pct lag 2	Percent deviation from contract, lagged twice	1.295830
4	fuel	Fuel type	1.350806
2	deviation pct lag 1	Percent deviation from contract, lagged once	1.665891
16	target lag 2	Indicator deviation from contract, lagged twice	1.679498
17	targetd num	Number of deviations in last two periods	2.642445
15	target lag 1	Indicator deviation from contract, lagged once	3.482694

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Test system

Table 1 : General Characteristics of System Being Used

	Area	Buses	Total Gens	Online Gens	Total load	Fixed loads	Branches
1	1	104	35	35	98	98	132
2	2	60	6	6	56	56	75
3	3	159	28	28	114	114	207
4	4	10	6	6	7	7	10
5	5	96	34	34	78	78	117
6	6	87	34	34	68	68	109
7	7	138	20	20	114	114	194
8	8	74	3	3	65	65	99
9	9	74	0	0	64	64	97
10	10	791	110	110	736	736	976
11	11	181	73	73	158	158	217
12	12	40	10	10	6	6	31
Total		1814	359	359	1564	1564	2264

Low Score generators

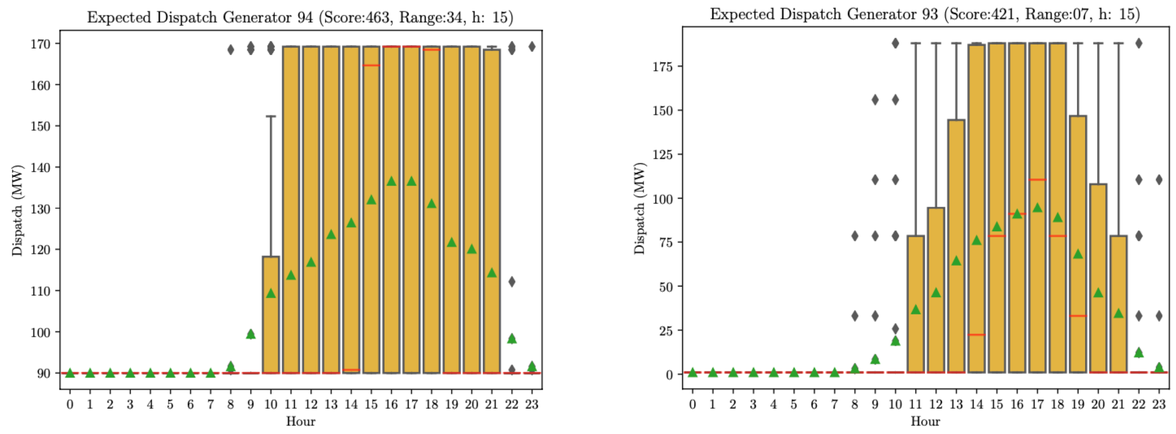


Figure 3 Two Natural gas generators, low vs. high range, low score

Ranges

- Median: green triangle
- Outliers: diamonds
- The average dispatch over 50: red
- Box: 25-75 percentile of dispatch realizations

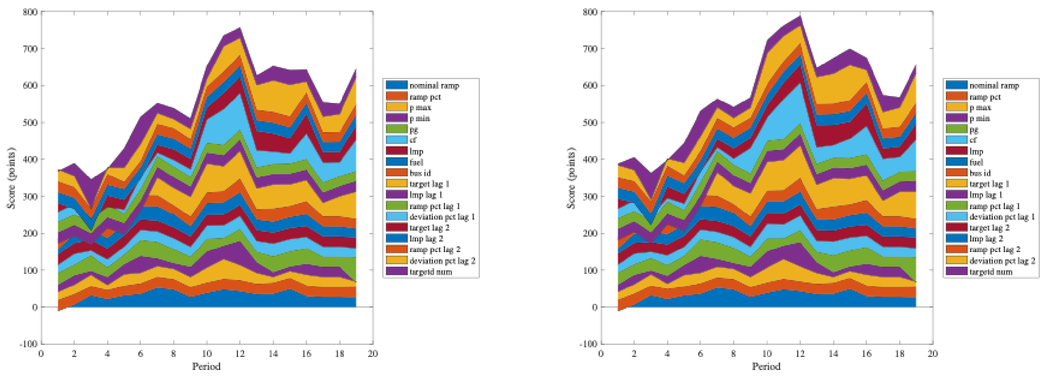


Figure 8 Score Composition for two natural gas generators (215 and 219), high scores at h15

High Score Generators

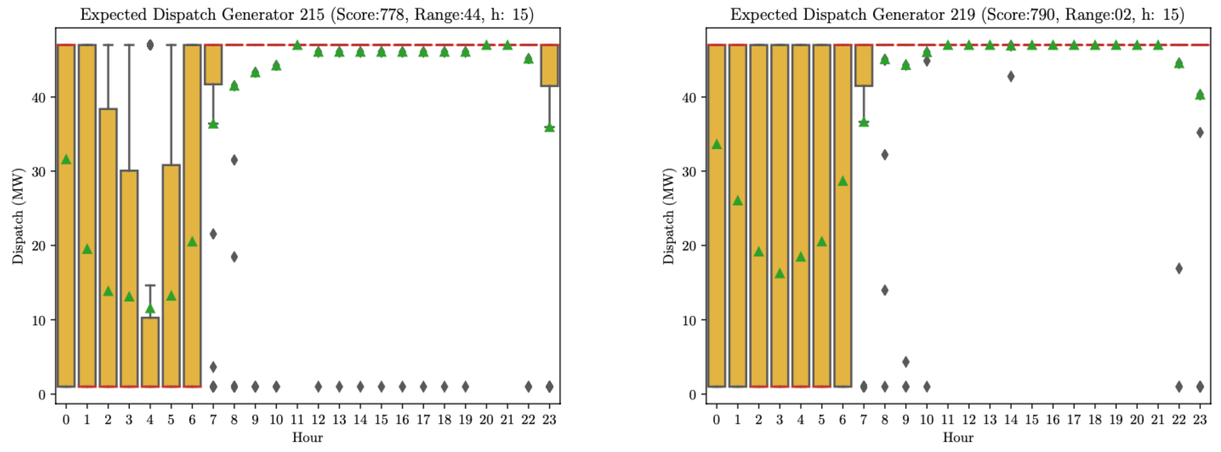
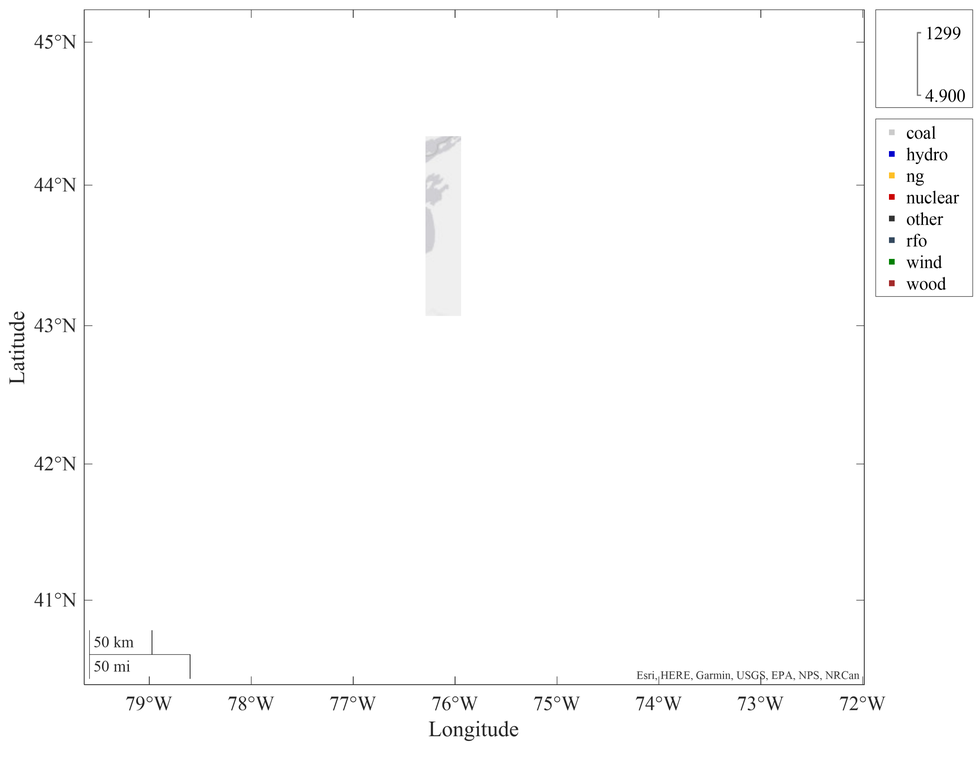


Figure 5 Two Natural Gas Generators, low vs. high range, high score

Study area

- Generation fleet 2019



CO_2 rate (tons/mmBtu) - NO_X rate (lbs/mmBtu) - SO_2 rate (lbs/mmBtu)

Principal Component Estimation:

$$\mathbf{w}_{(1)} = \arg\max \left\{ \frac{\mathbf{w}^T \mathbf{X}^T \mathbf{X} \mathbf{w}}{\mathbf{w}^T \mathbf{w}} \right\}$$

$$\mathbf{w}_{(k)} = \arg\max \left\{ \frac{\mathbf{w}^T \hat{\mathbf{X}}_k^T \hat{\mathbf{X}}_k \mathbf{w}}{\mathbf{w}^T \mathbf{w}} \right\}$$

Input Variables[1]:

- Heat Input (mmBtu)
- Nameplate Capacity (MW)
- Nameplate Power Factor
- Summer Capacity (MW)
- Principal Component Analysis
  - PG
  - QG
  - ...
- Winter Capacity (MW)
- Minimum Load (MW)
- Latitude
- Longitude
- Generator Type
- Fuel Type
- County
- Generator Fuel Type

[1] *Transformed numerical input variables to generate a matrix consisting of all polynomial combinations of the features with degree less than or equal to the specified degree*

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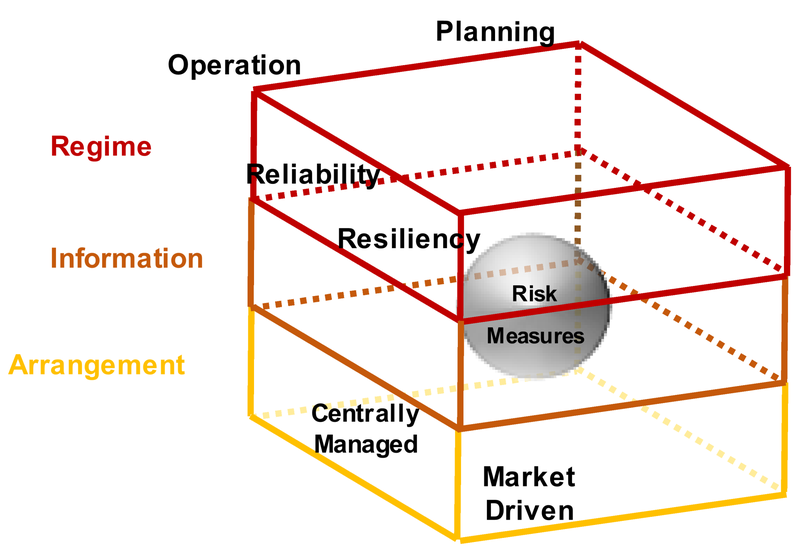
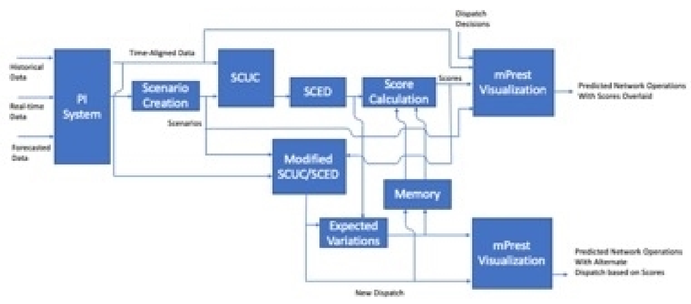
Forecasting renewables

ABSCoRES model



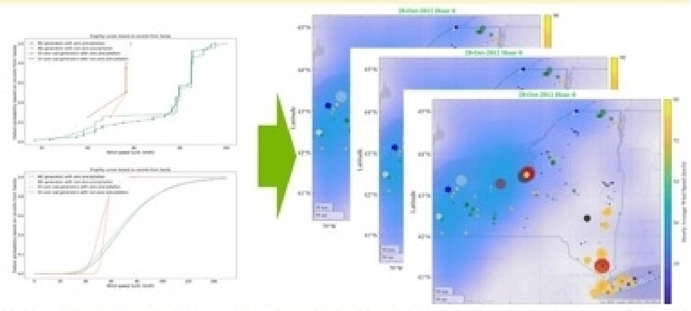
Integrate Into Data Analytics Platforms:
ABSCoRES risk score calculation integrated into data analytics and visualization platforms currently used by utilities and grid operators. Possibly integrate with SCED/SCUC.



Formation of Electric Assets Risk Bureau:
- **Independent entity**
- **Embeds ABSCoRES risk score calculation methodology**
- **Advisory, coordination**
- **Software solutions assigning scores to assets**

Scores used by
- **Grid operators, ISOs**
- **Market participants**
- **Market monitors**
- **Regulators, evaluators**

Risk assessment:
- **Reliable**
- **Reproducible**
- **Equitable**



KEY INNOVATIONS

ONBOARDING ENTITIES INTO ABSCORES RISK SCORE CALCULATION PLATFORM

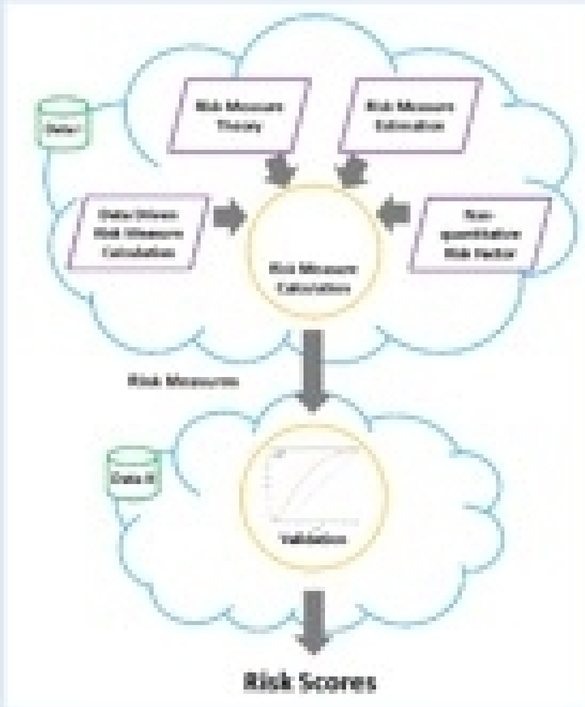
Onboarding: Transitional stage in which an entity joins risk bureau for risk assessment. Stage may be custom to each entity

Understand past data collection, requirements, and constraints

Identify usable data sets

Create scenarios, perturbations for assessing risk measures

ABSCORES RISK SCORE CALCULATION



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