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Power System Dynamic Security Analysis, Integrating Supervised Machine Learning Classification Approach

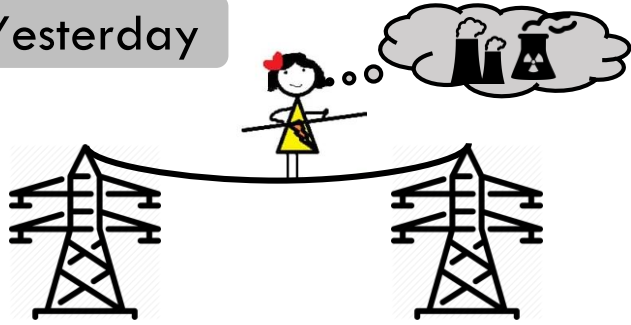
By Saeed Misaghian

University College Dublin, Dublin, Ireland

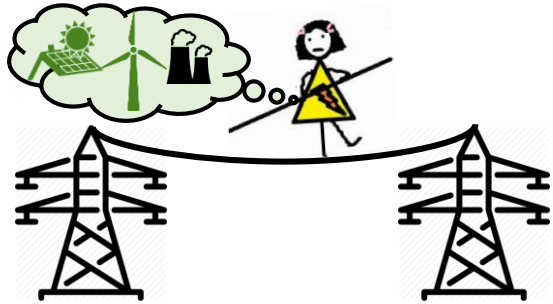


New System, New Challenges, New Needs

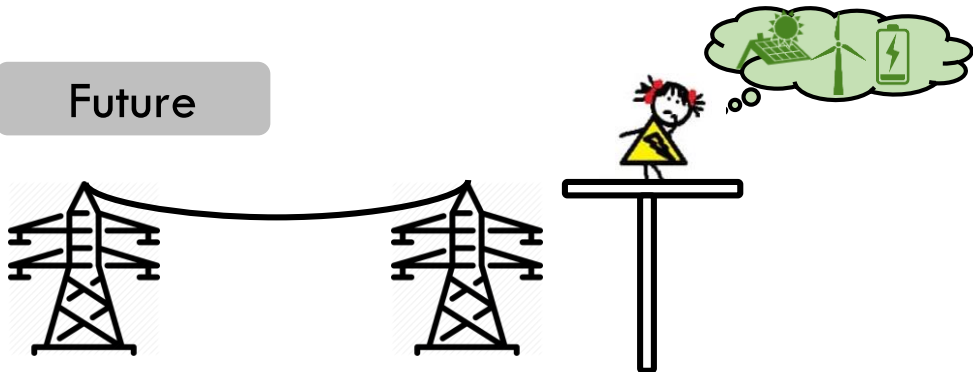
Yesterday



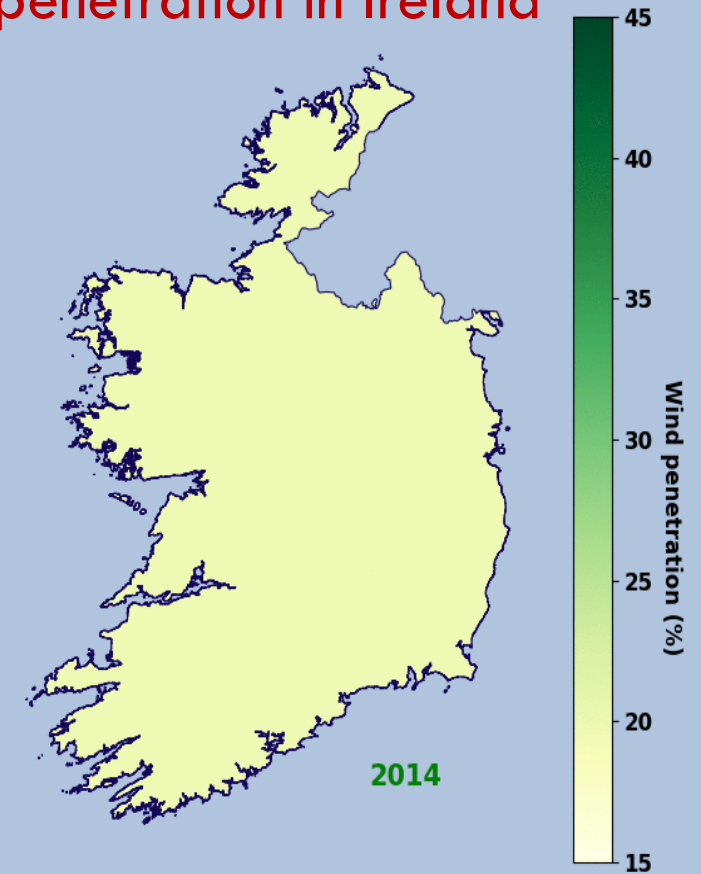
Today



Future



Mean (yearly) of wind
penetration in Ireland







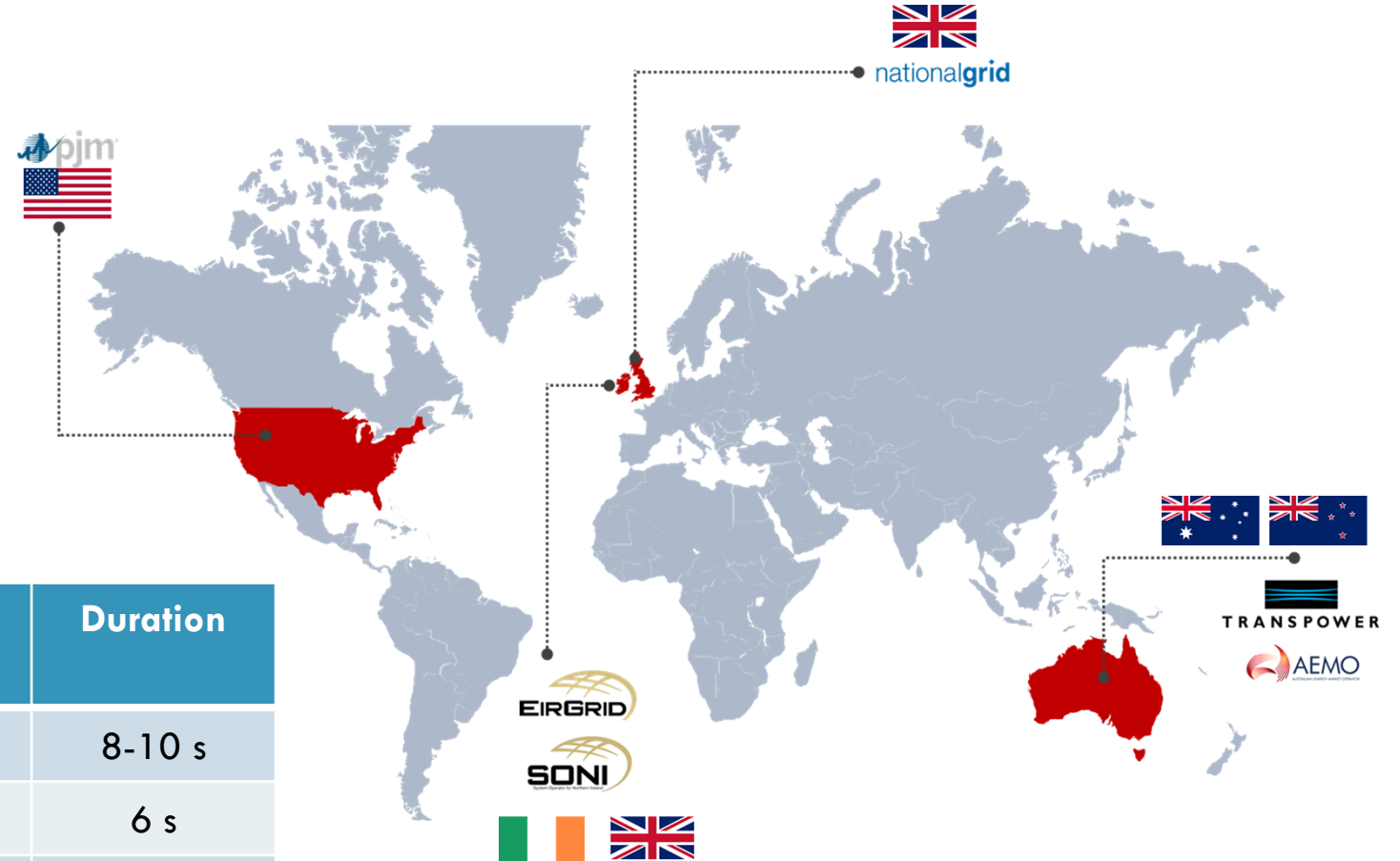
Source: <http://www.eirgridgroup.com>

By Saeed Misaghian & Ciara O'Dwyer

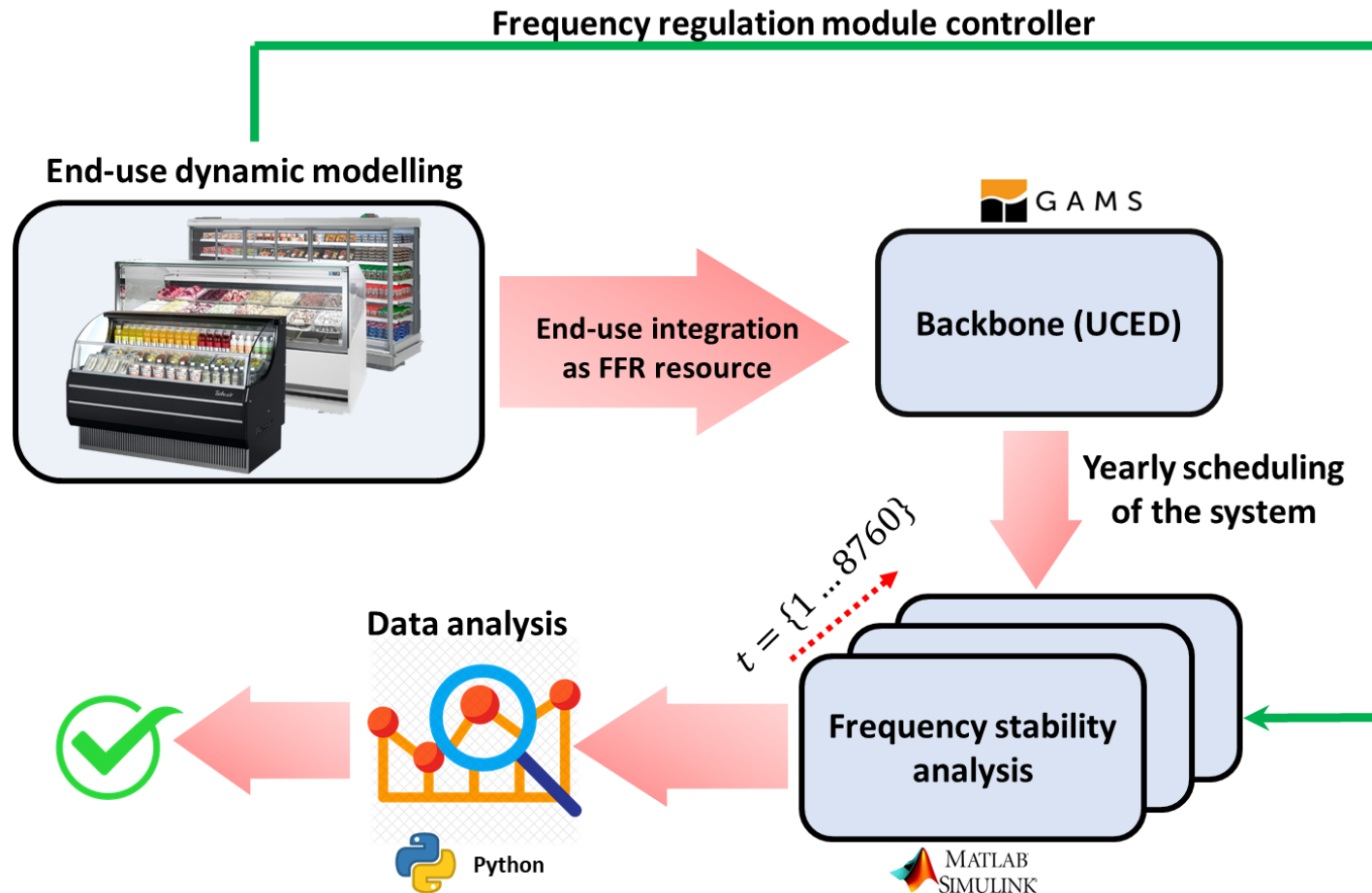
Fast Frequency Response (FFR)

FFR: Fast frequency response
 EFR: Enhanced frequency response
 RegD: Regulation D

Region	TSO	Service	Response Time (s)	Duration
	EirGrid	FFR	2	8-10 s
	AEMO	FFR	0.5-1	6 s
	National Grid	EFR	1	15 min
	PJM	RegD	2	Sustained

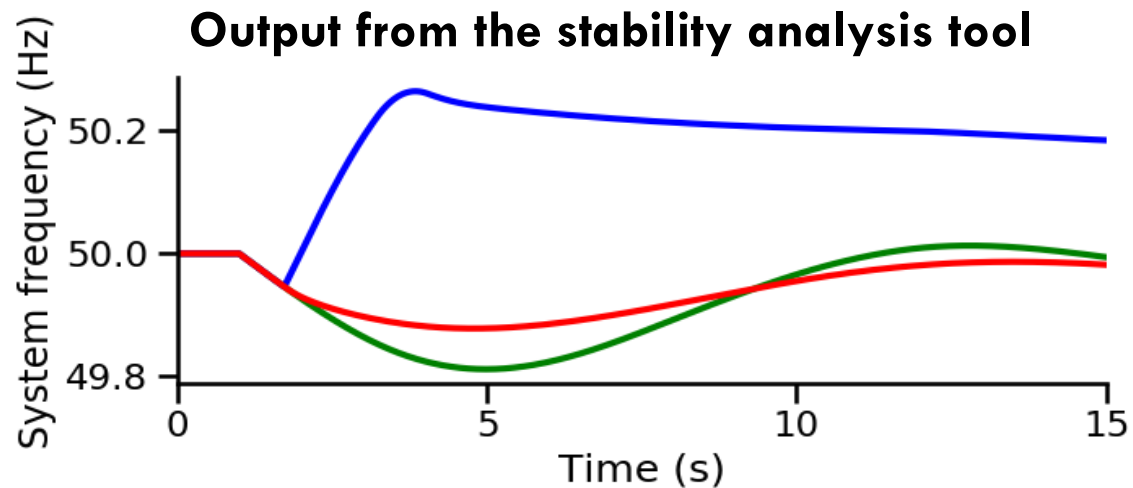
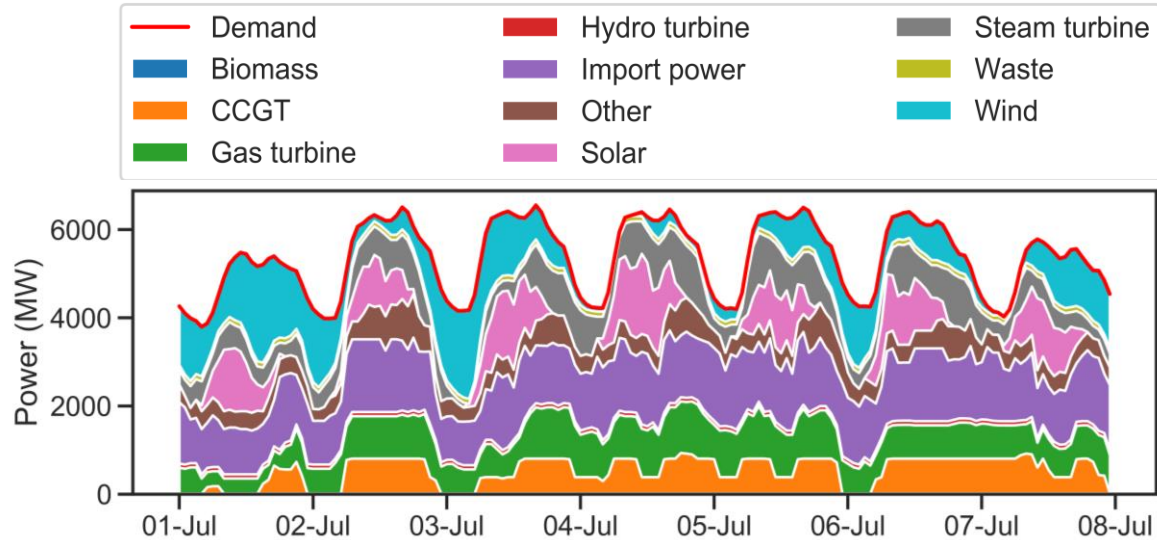


Model Overview



Outputs

Output from the optimisation tool



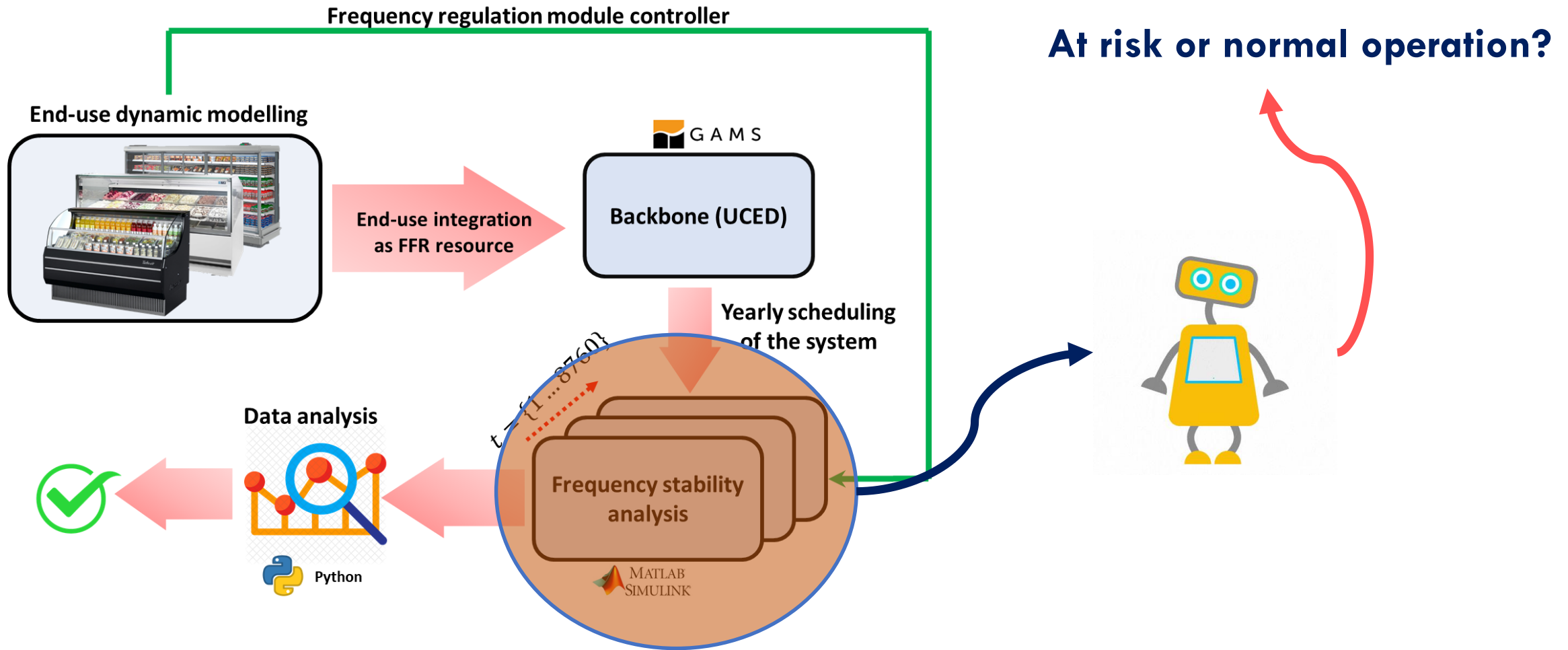
Each Yearly Scenario:

- **72 hours- stability analysis**

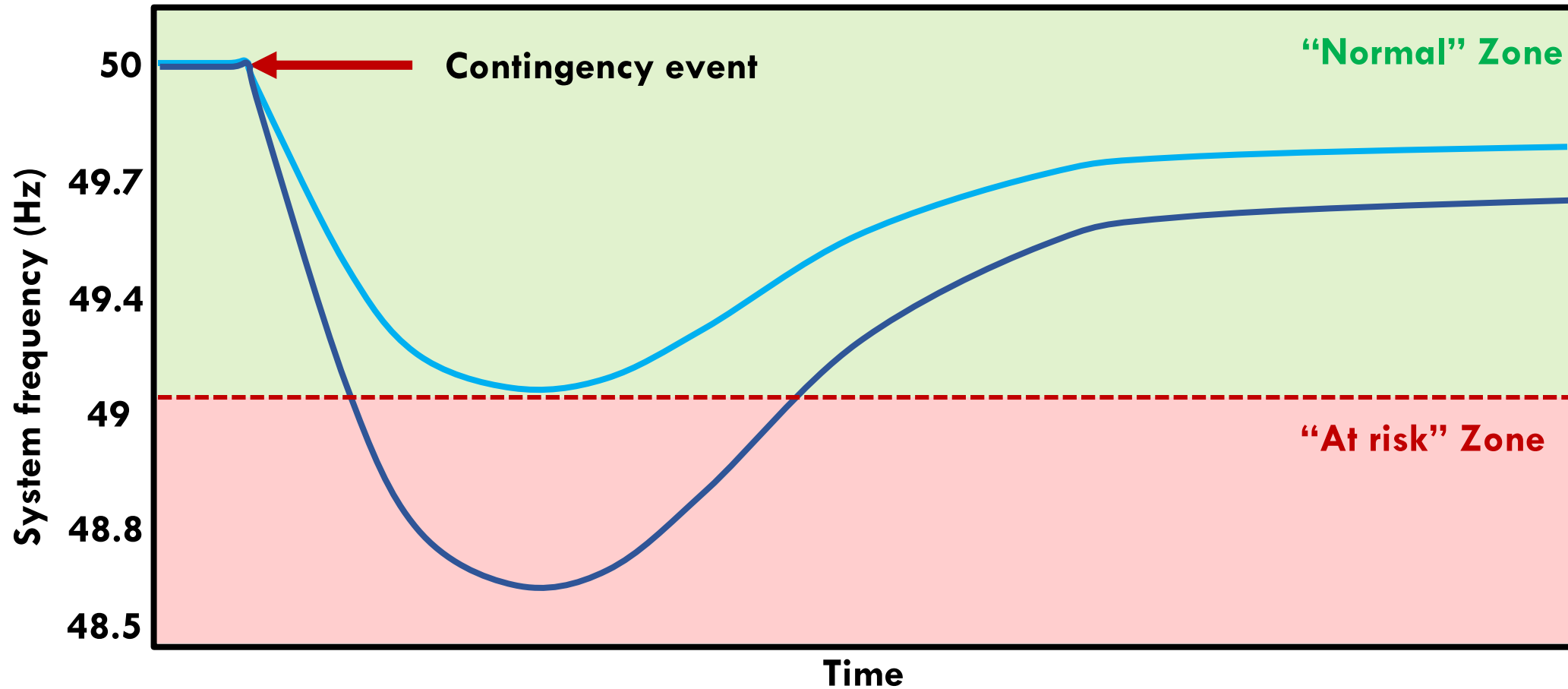
X 3 scenarios for FFR

216 hours only for stability analysis!

Applying Machine Learning



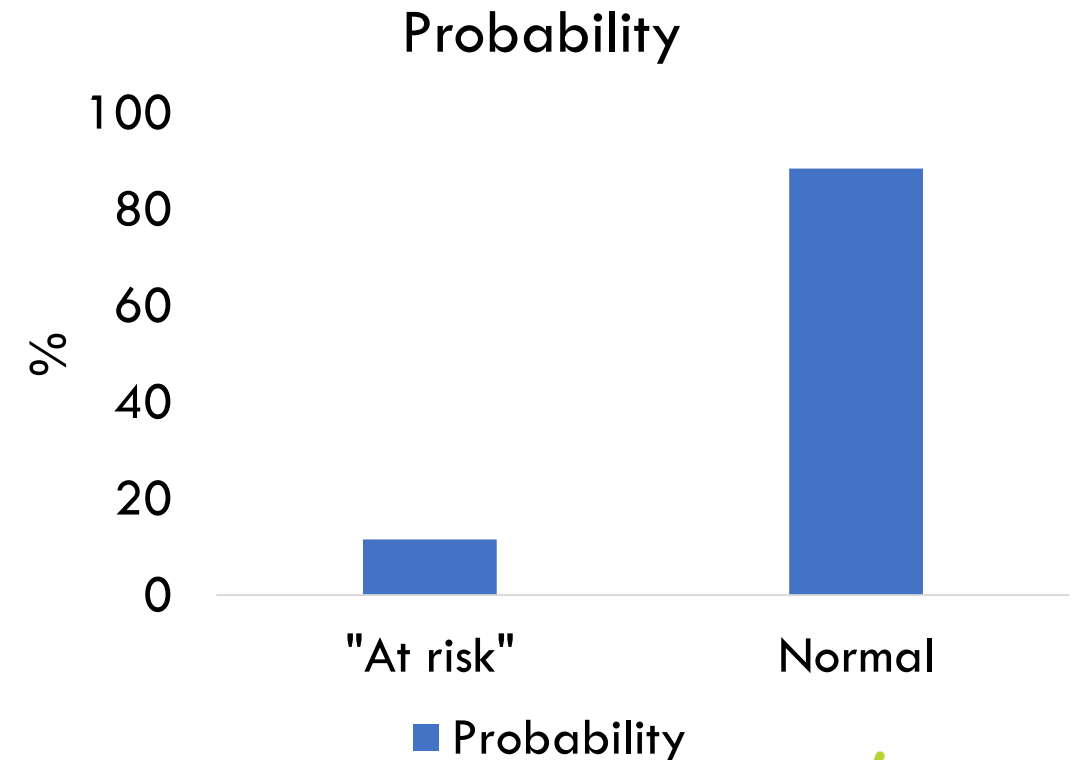
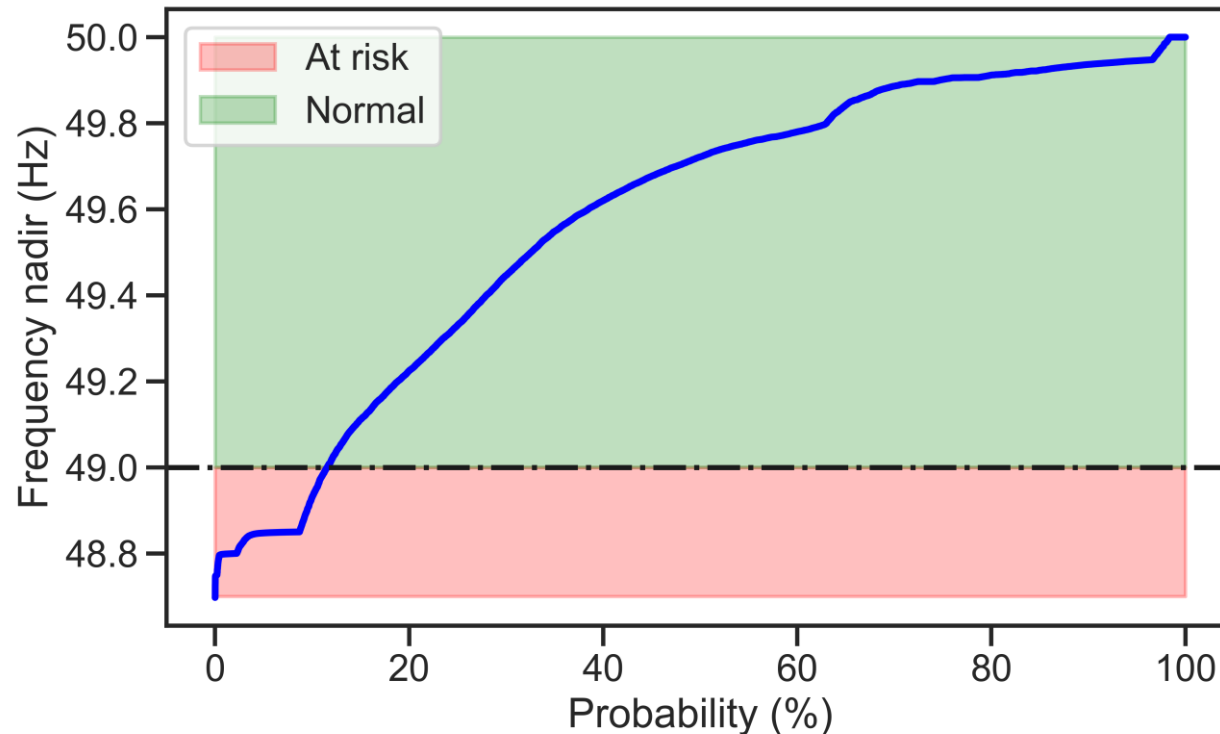
System Frequency Following a Contingency



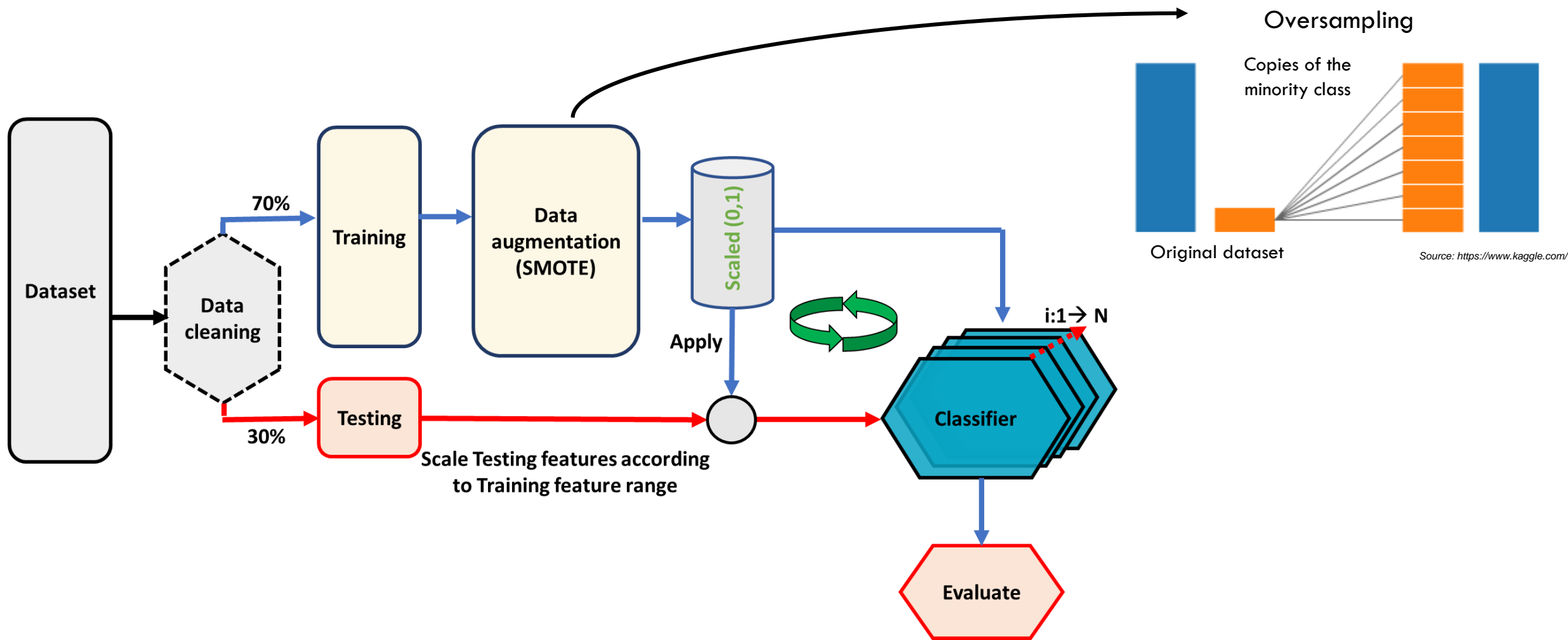
Imbalanced Dataset



- “At risk” operation: ~12 % of dataset
- Normal operation: ~88 % of dataset



Machine Learning Framework



SMOTE: Synthetic Minority Over-sampling Technique

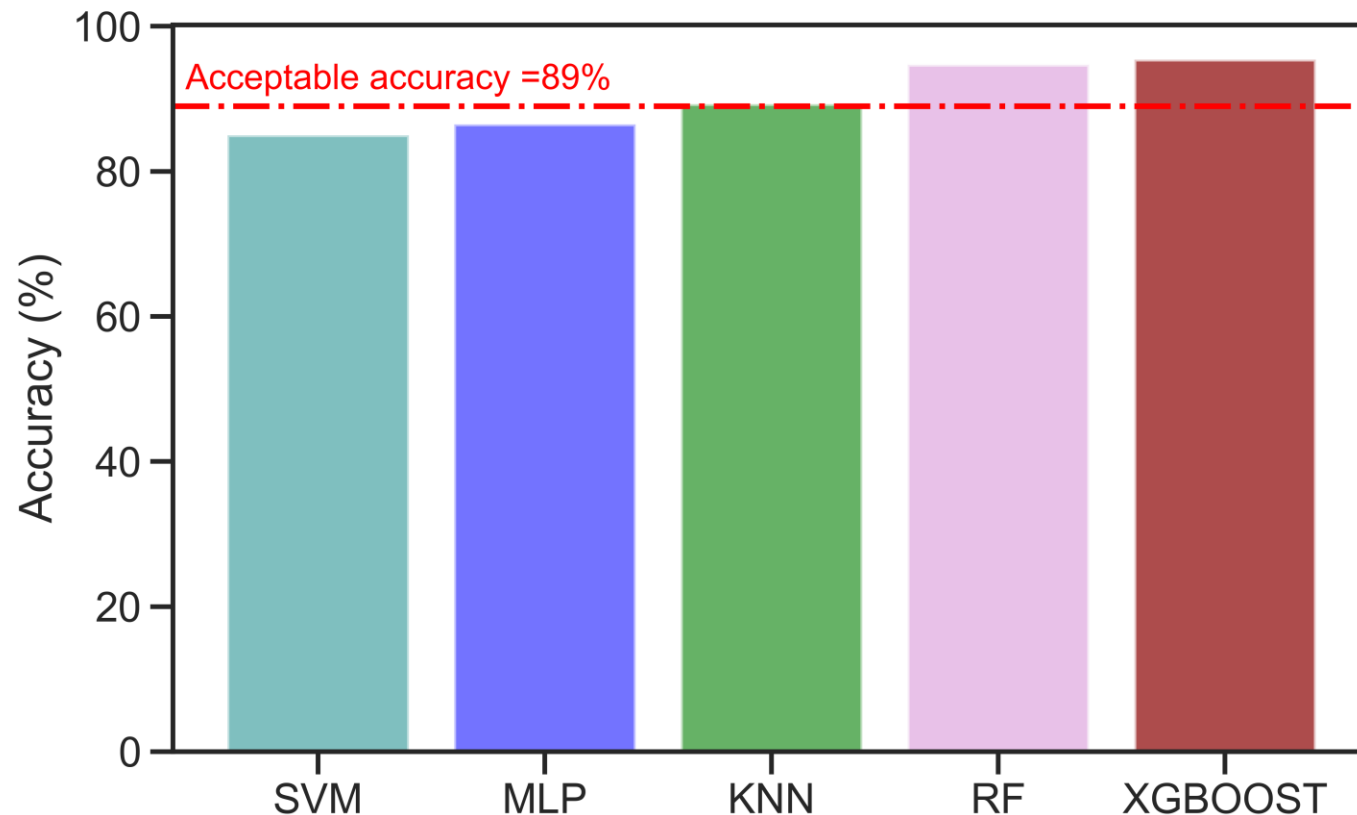
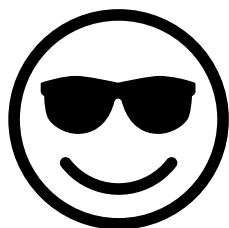


Machine Learning Methods

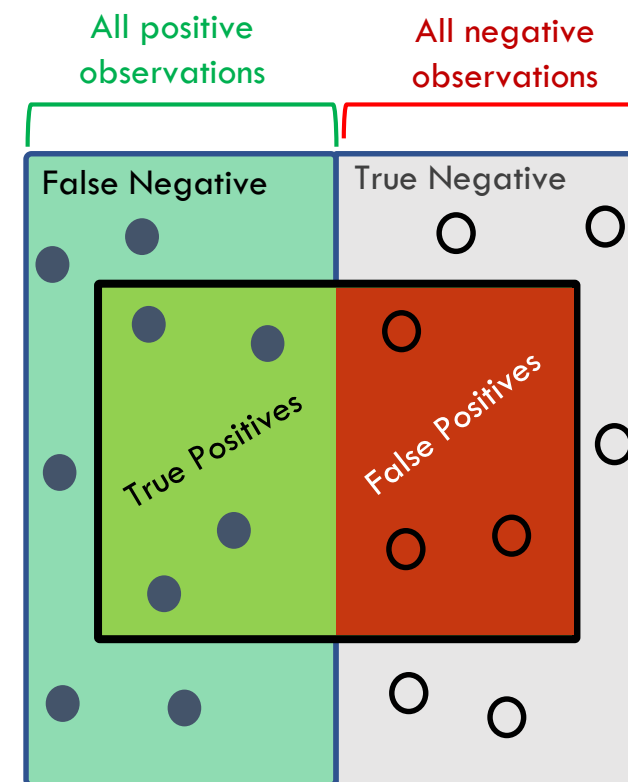
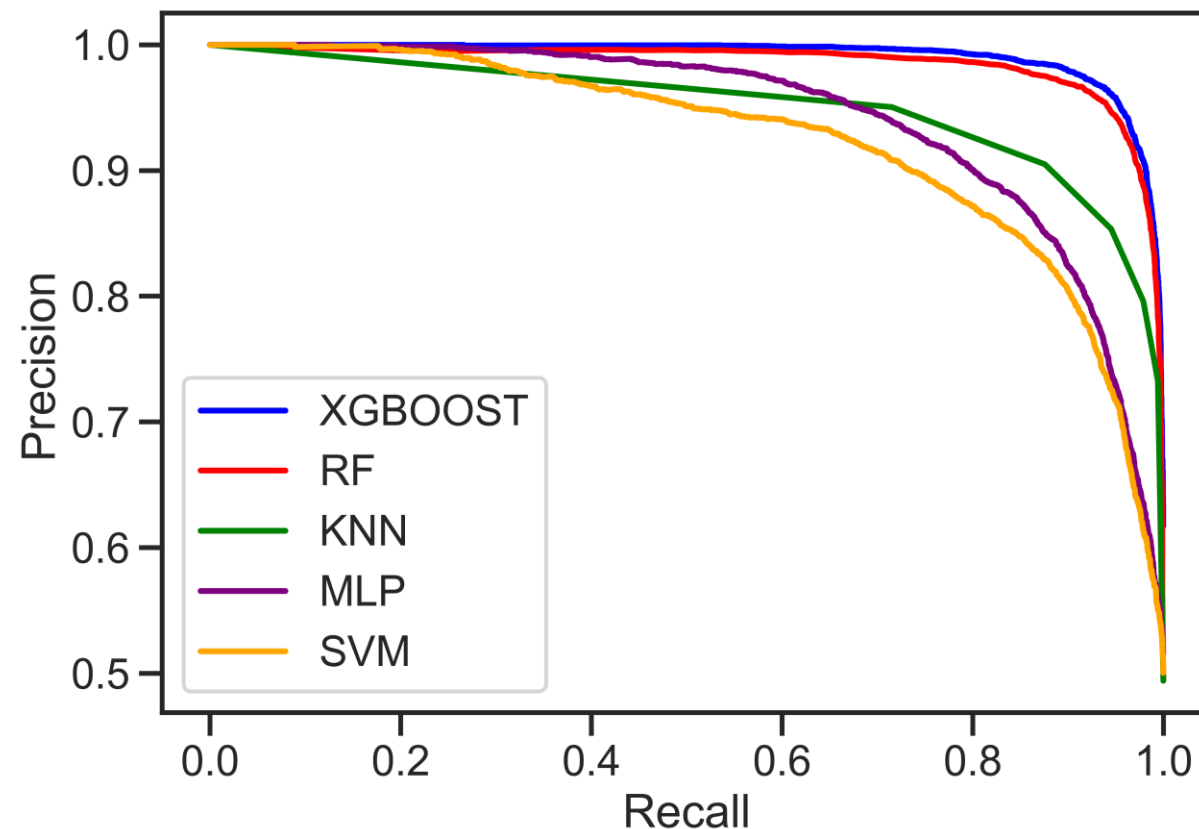


- SVM: Support vector machine
- MLP: Multilayer perceptron
- KNN: k-nearest neighbors
- RF: Random forest
- XGBOOST: Extreme gradient boosting

Run-time <1 sec !!!



Machine Learning Outputs

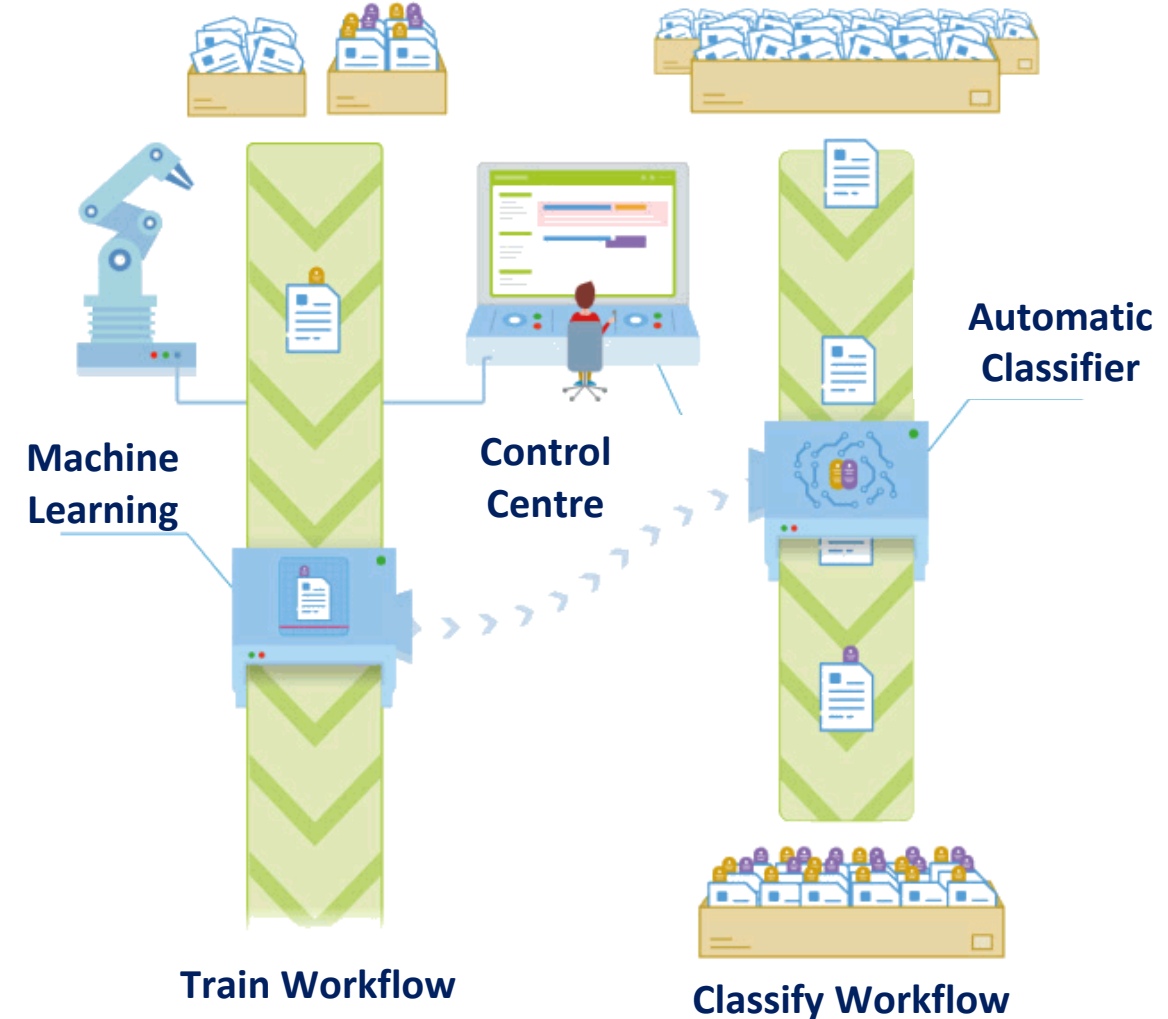


$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$
$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

Conclusion



- Replacing stability analysis tool with an ML model
- Reducing computational time significantly
- High accuracy and performance
- Rapid check of power system dynamic security



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Thank you for your attention...

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