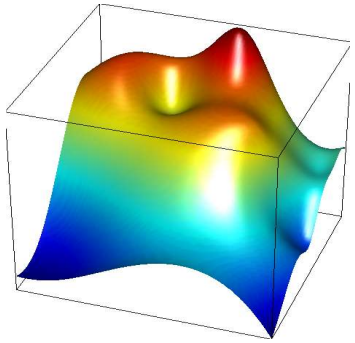
Save the Earth: Accelerate Climate Science and Electrify Everything

Dr Tanya Morton
Global Director Customer Success Engineering, MathWorks
8 November 2024

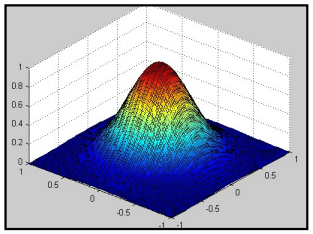
Tanya Morton – Education

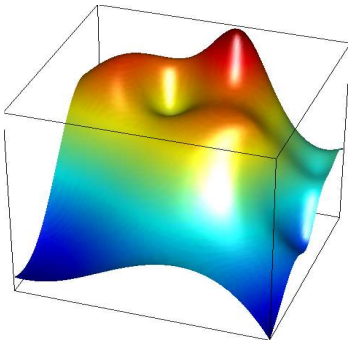
1995
BA Mathematics
Oxford University
UK

2000
PhD Mathematics & Computer Science,
Vanderbilt University,
USA



Thesis: Error Bounds for Solving Pseudodifferential Equations on Spheres by Collocation with Zonal Kernels





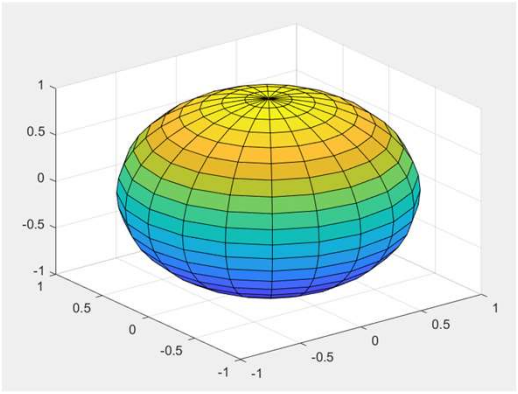
RBFs

My PhD

Spheres

PDEs

$$\nabla^2 f = h$$



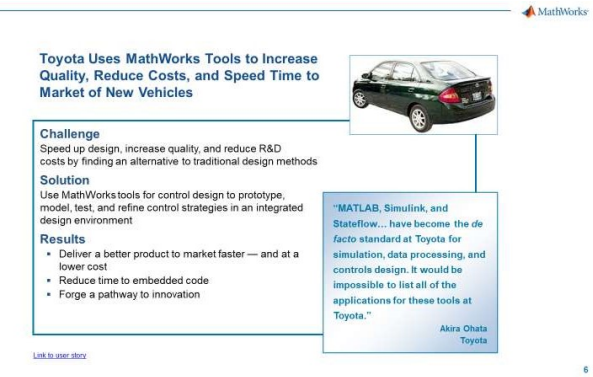
Spherical Interpolation Convergence Order Result

- ψ is a conditionally positive definite function of order m on the unit sphere S^{d-1} whose Legendre coefficients decay like $(1+k)^{-(1+\alpha)}$ for some α > 0
- Ξ denotes a set of distinct data points on S^{d-1} with geodesic mesh-norm h
- There exists a positive number h_0 such that, if h ∈ (0, h_0) then the ψ−based Spherical Basis Function interpolant sf to target function $f \in W^{2s}(S^{d-1})$ satisfies

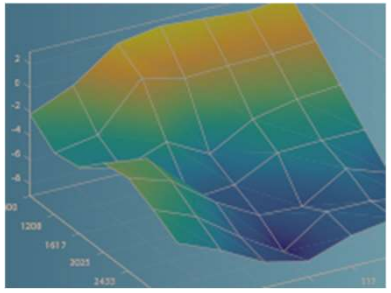
$$\|f - sf\|_{W^s(S^{d-1})} \leq C\, h^s \|f\|_{W^{2s}(S^{d-1})}$$

where 2s = α + d -1 and the generic constant C is independent of h

Tanya Morton - MathWorks Experience



- 2000 – 2005 Consultant
  - Developed AI and Optimization capability for the Model-Based Calibration (MBC) Toolbox
  - Worked with global automotive companies
- 2005 – 2015 Application Engineering Manager
  - Supported aerospace, automotive, energy companies, plus universities
- 2019 – 2024 Director Customer Success Engineering
  - Supporting students, educators and researchers, team based in 16 countries and 30+ cities



MATLAB EXPO

SAVE THE EARTH

ACCELERATE CLIMATE SCIENCE

AND

ELECTRIFY EVERYTHING

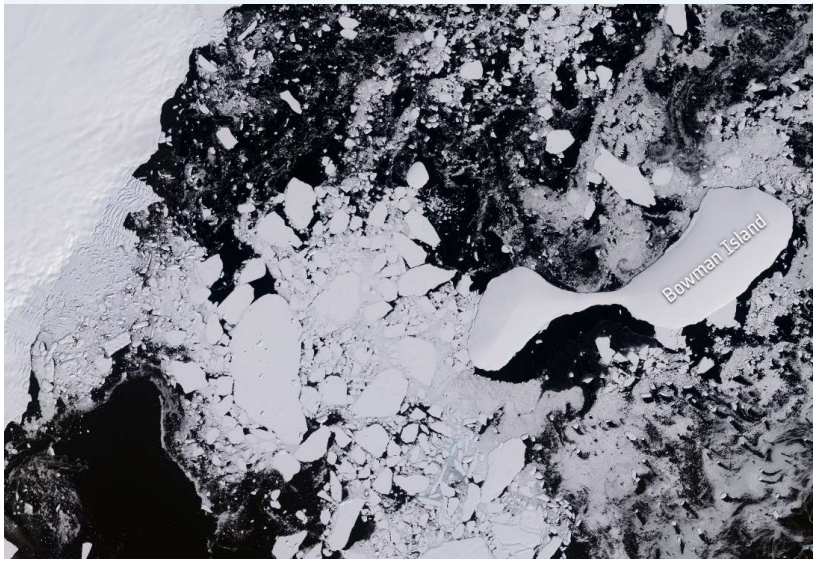
Dr. Tanya Morton

Director, MathWorks

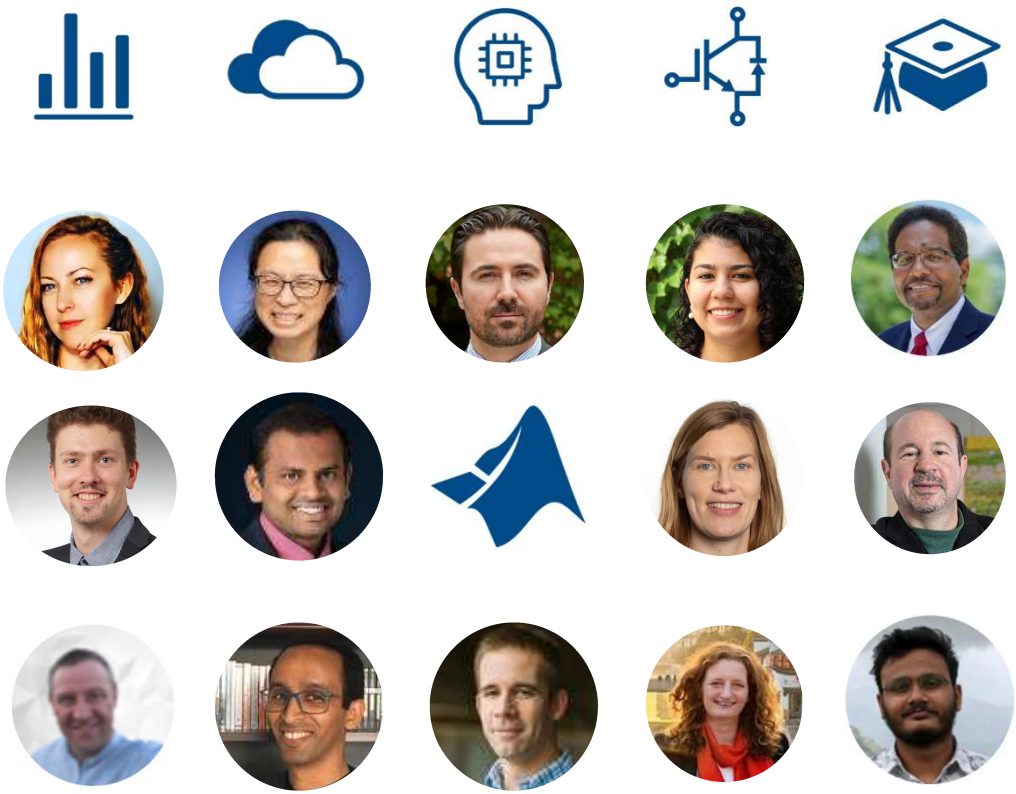
Ice shelf bigger than New York City breaks off eastern Antarctica

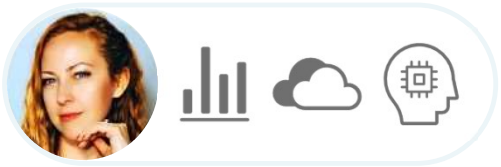
The Conger Ice Shelf is the first to break off eastern Antarctica in four decades of satellite observations.

— The Washington Post



Credit: Copernicus Sentinel data (2022), processed by ESA, CC BY-SA 3.0 IGO





Research

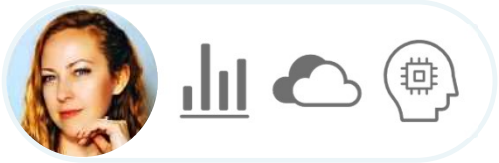
Accelerate Climate Science

Education

Train the Next Generation

Industry

Electrify Everything



Research

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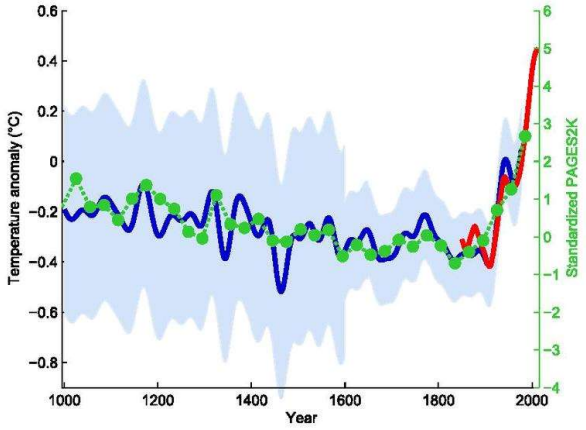
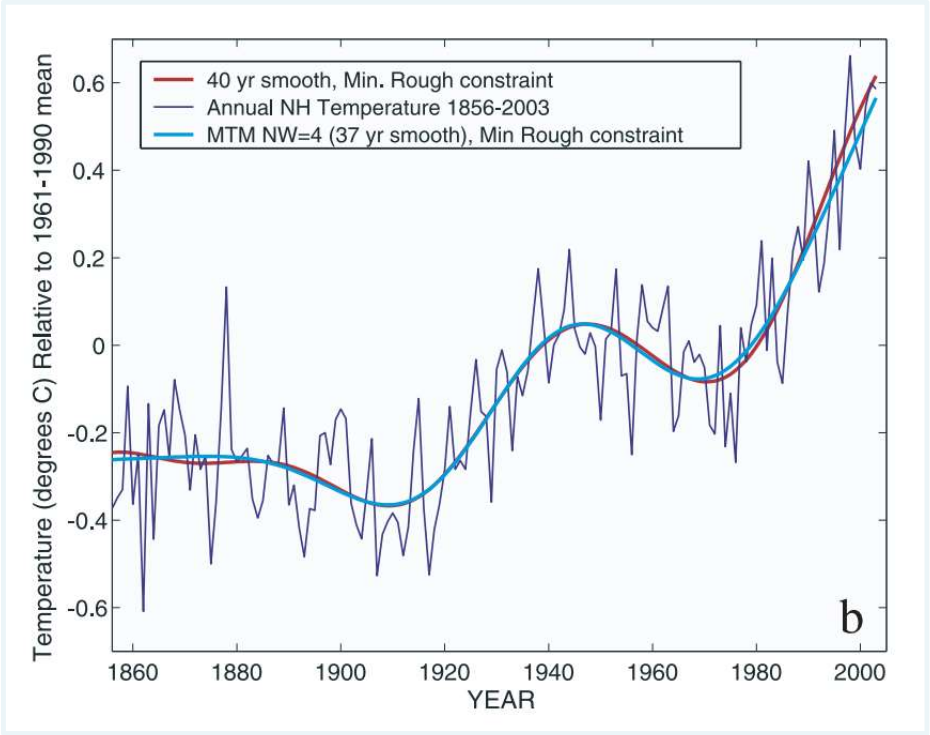
Climate Science Trends

Prof. Michael E. Mann



Uncovering Climate Change Signals in Noisy Data

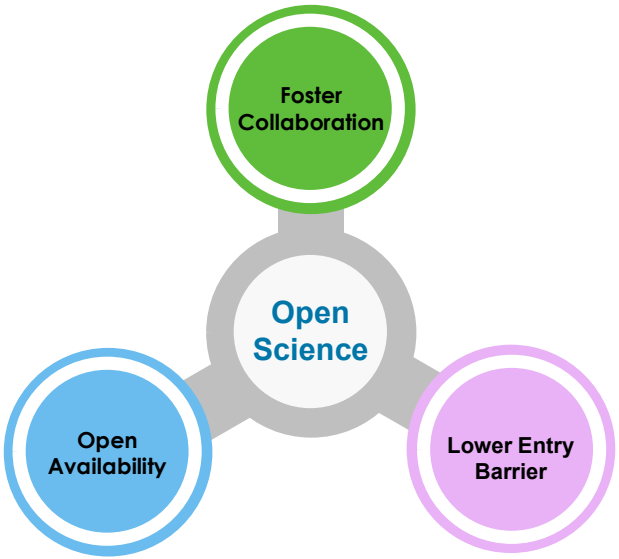


Data availability

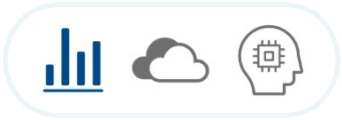
All raw data and results are available at the supplementary website:
http://www.meteo.psu.edu/~mann/supplements/Mann_MTMSVD_2019/Data.

Code availability

All ©Matlab code is available at the supplementary website:
http://www.meteo.psu.edu/~mann/supplements/Mann_MTMSVD_2019/Code.




MATLAB EXPO
November 13–14, 2024 | Online
Register
The event is free, but registration is required.



Algorithm Development
and Data Analysis

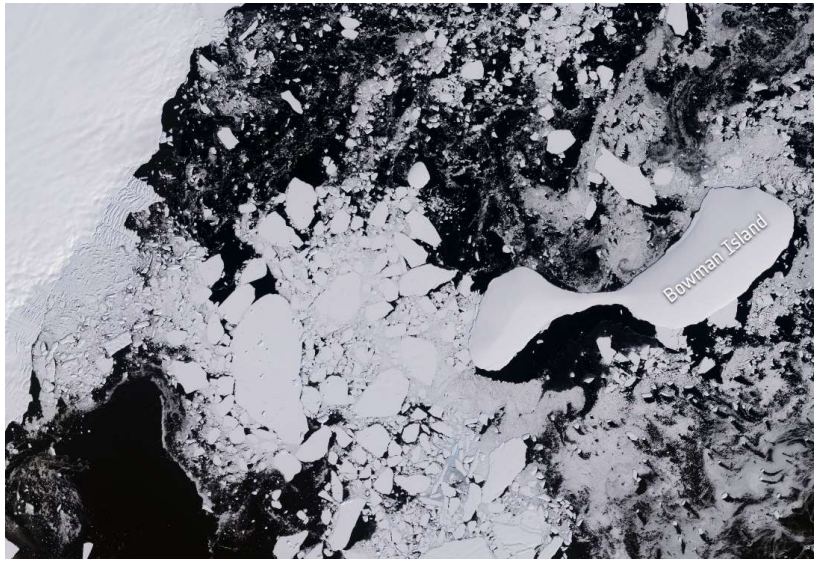
FIND OUT MORE

OPEN SOURCE SOFTWARE AND MATLAB: PRINCIPLES, PRACTICES, AND PYTHON

Dr. Heather Gorr, MathWorks

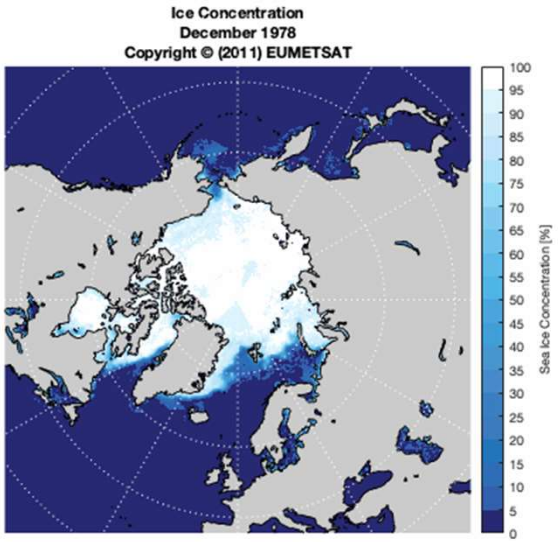
Dr. Mike Croucher, MathWorks

Climate Science Cloud Portals



Copernicus

Climate Science Cloud Portals



Predict Droughts with AI

Dr. Jan Adamowski, McGill University

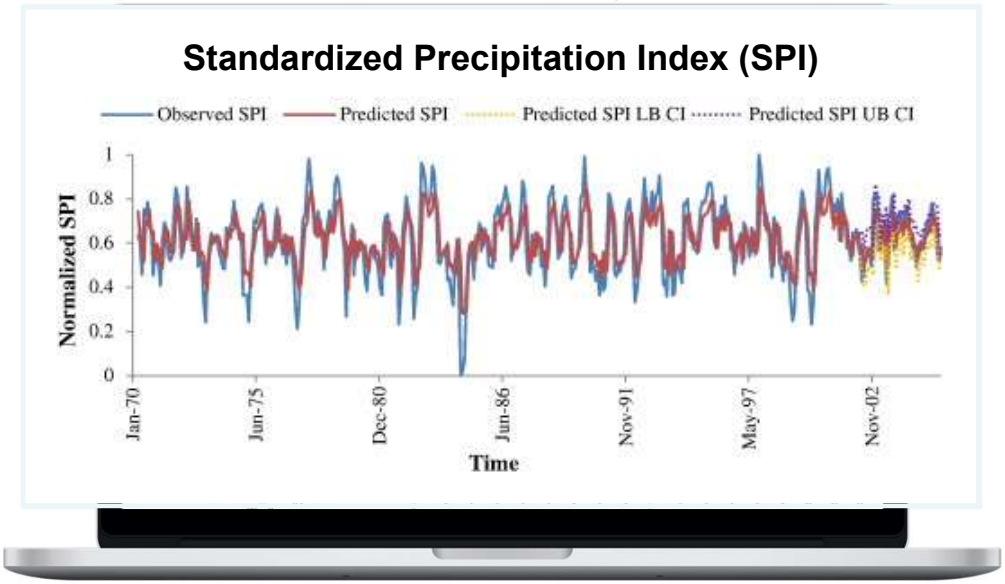
Anteneh Belayneh, Carleton University

Dr. John Quilty, University of Waterloo

Bousnobra Khalil, University of Guelma

Awash River, Ethiopia

Artificial Neural Networks



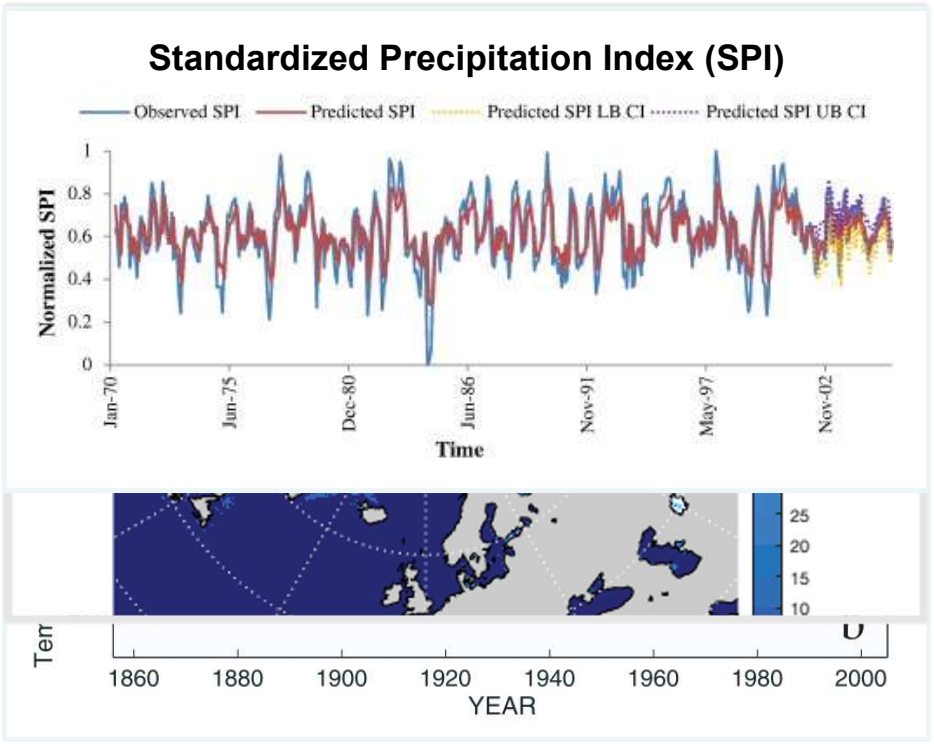
Hands-On Workshop

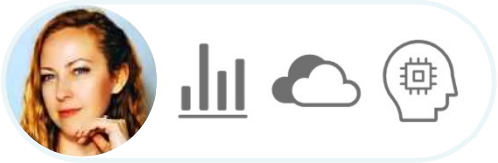
FIND OUT MORE

OPTIMIZING AI-ENABLED BIOMEDICAL SIGNAL PROCESSING ALGORITHMS

Dr. Brenda Zhuang, MathWorks

Akhilesh Mishra, MathWorks


Standardized Precipitation Index (SPI)
Observed SPI
Predicted SPI
Predicted SPI LB CI
Predicted SPI UB CI
Normalized SPI
1
0.8
0.6
0.4
0.2
0
Jan-70
Jun-75
Dec-80
Jun-86
Nov-91
May-97
Nov-02
Time
25
20
15
10
1860
1880
1900
1920
1940
1960
1980
2000
YEAR



Research

Accelerate Climate Science

Education

Train the Next Generation

Industry

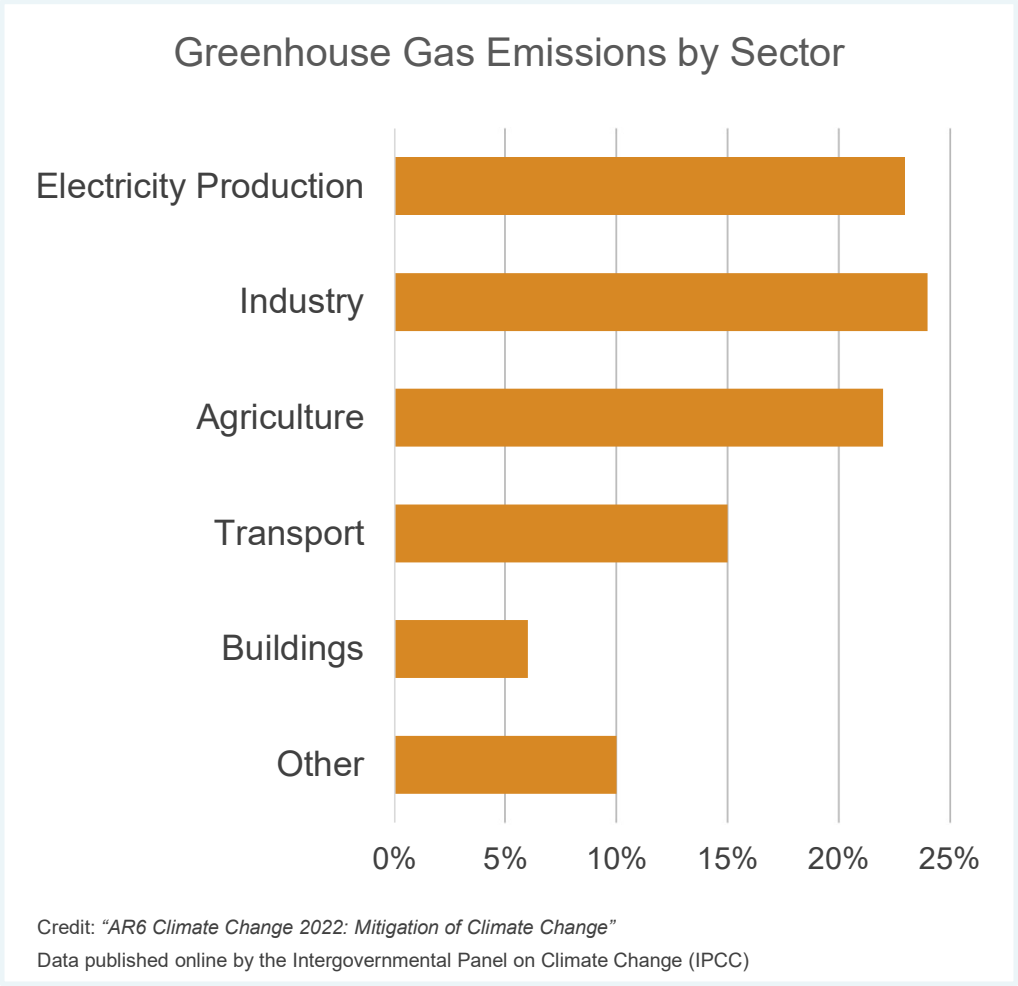
Electrify Everything

Circumstances Affecting the Heat of the Sun's Rays

American Journal of Science and Arts

Series 2: Volume 2 (1856)

Eunice Newton Foote



Credit: *"AR6 Climate Change 2022: Mitigation of Climate Change"*
Data published online by the Intergovernmental Panel on Climate Change (IPCC)


CO_2

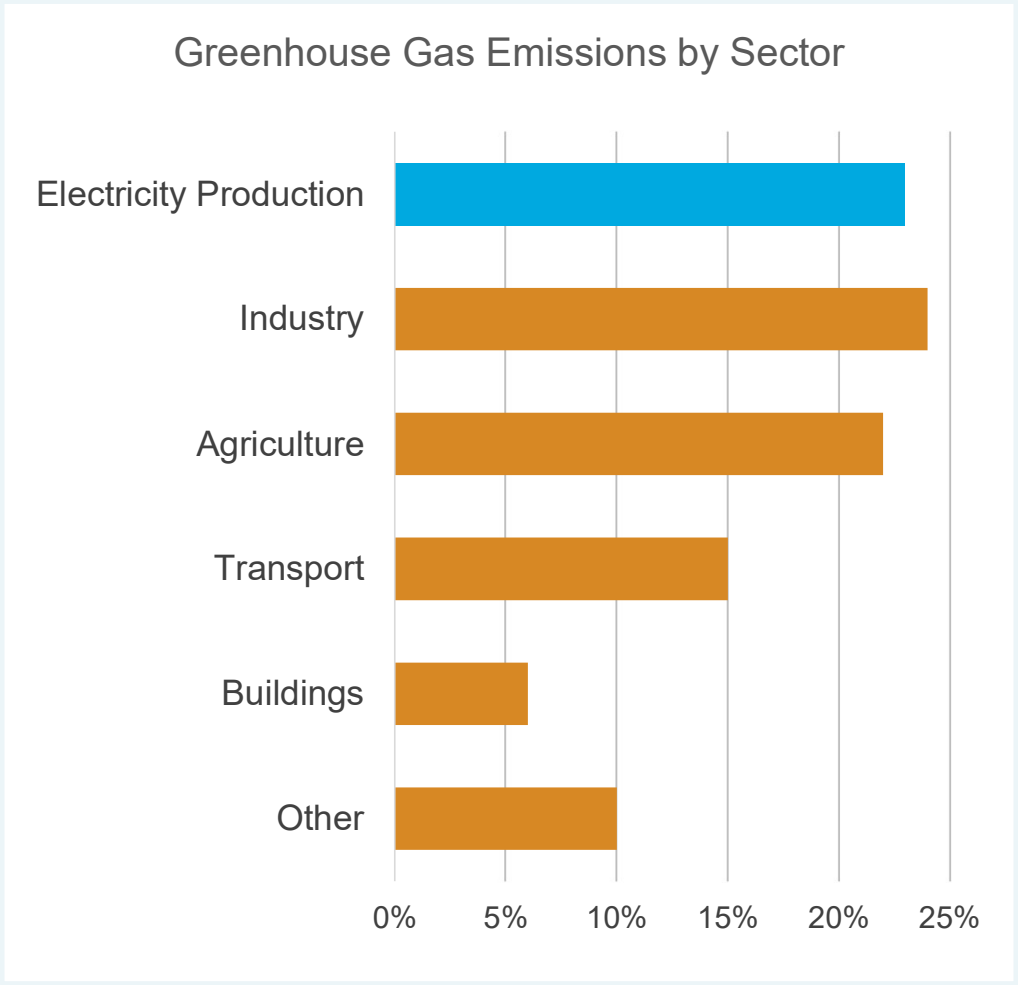
Generate electricity from renewable sources

+

Use electricity as our primary energy source

=

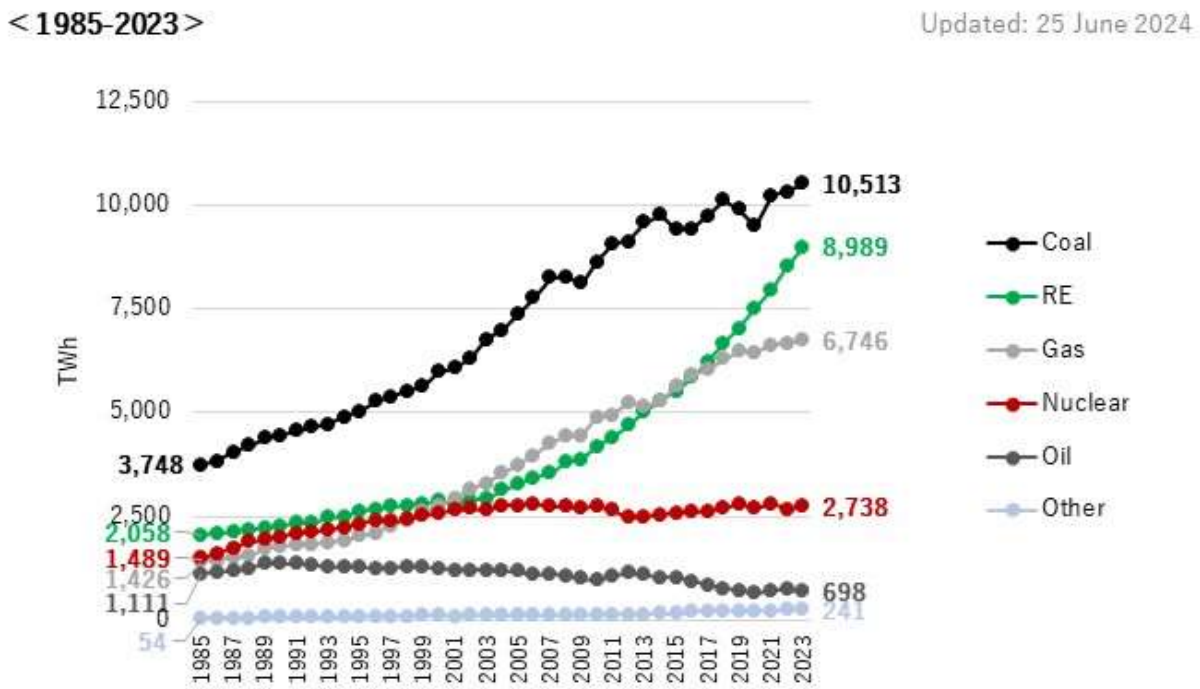
Electrify everything!


Greenhouse Gas Emissions by Sector
Electricity Production
Industry
Agriculture
Transport
Buildings
Other
0%
5%
10%
15%
20%
25%

Growth of the Electric Power Grid

Growth of the Electric Power Grid

Worldwide Electricity Production by Source

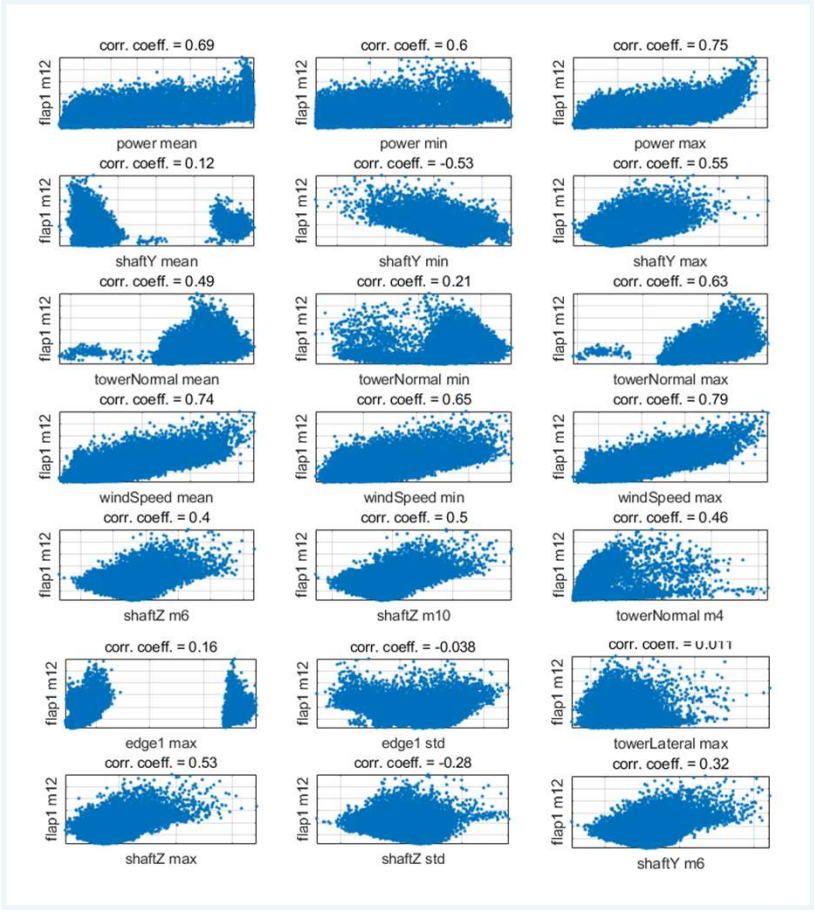


Notes: "RE" (renewable energy) includes hydro, wind, solar, bioenergy and geothermal. "Other" includes pumped hydro, other fossil generation, and statistical differences. Based on "gross" generation.

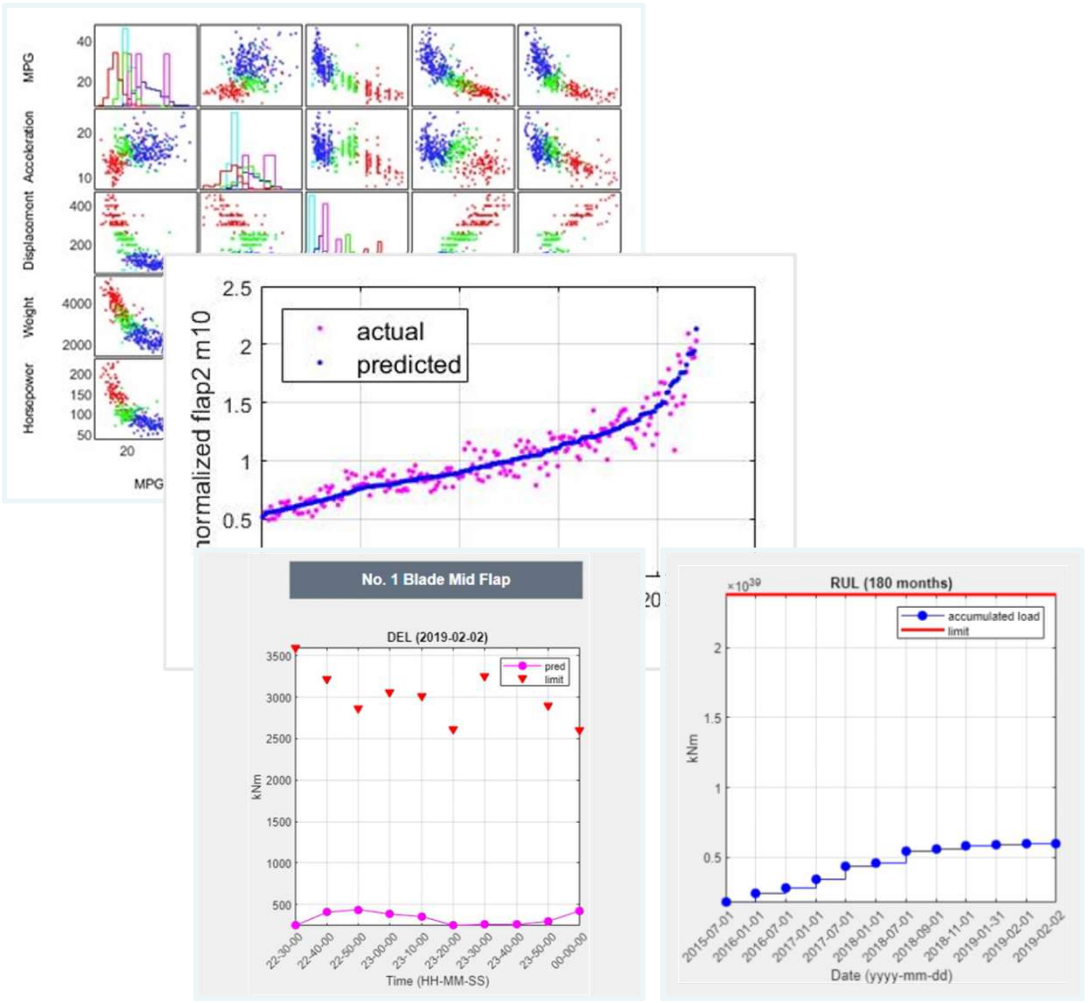
Source: Energy Institute, Statistical Review of World Energy 2024 (June 2024) (downloaded 21 June 2024).

8,000+ Components

3,000+ Signals

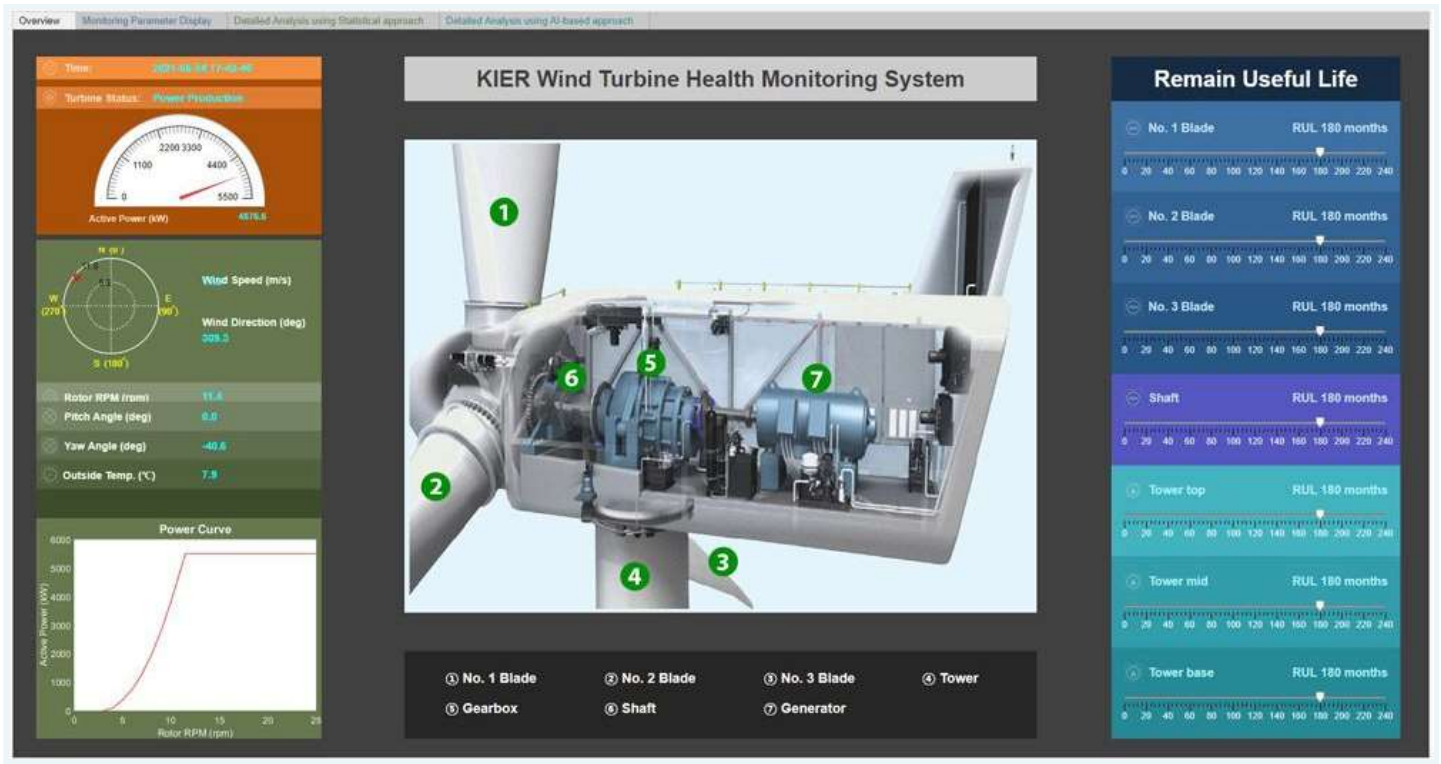


Courtesy of Korea Institute of Energy Research (KIER)


MPG
Acceleration
Displacement
Weight
Horsepower
actual
predicted
No. 1 Blade Mid Flap
DEL (2019-02-02)
pred
limit
kNm
Time (HH-MM-SS)
RUL (180 months)
accumulated load
limit
kNm
Date (yyyy-mm-dd)

> “Despite having little previous experience with AI... we completed a diagnostics model in MATLAB capable of detecting wind turbine component failure with over 90% accuracy.”

—Jung Chul Choi, senior researcher at Korea Institute of Energy Research



Courtesy of Korea Institute of Energy Research (KIER)

Access Data

- Sensors
- Files
- Databases

Analyze Data

- Data exploration
- Preprocessing
- Domain-specific algorithms

Develop

- AI model
- Algorithm development
- Modeling & simulation

Deploy

- Desktop apps
- Enterprise systems
- Embedded devices

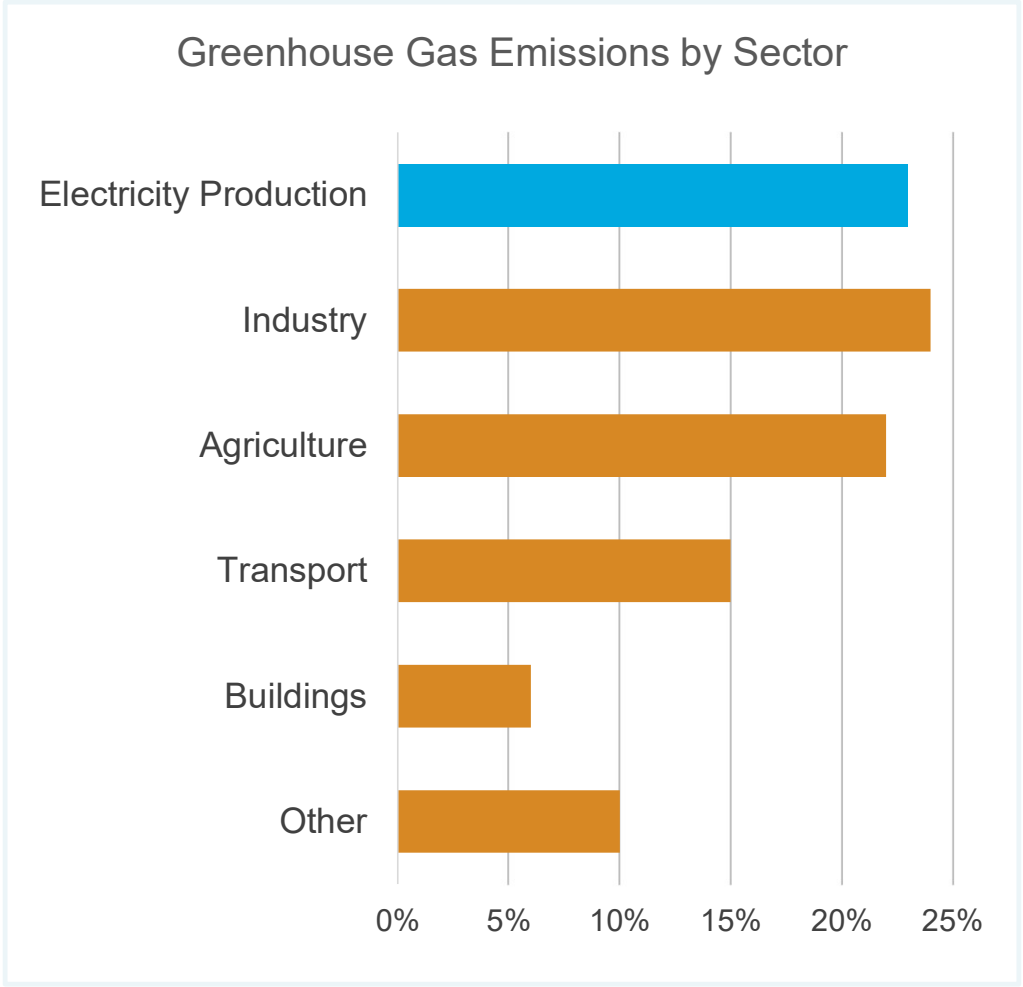
FIND OUT MORE

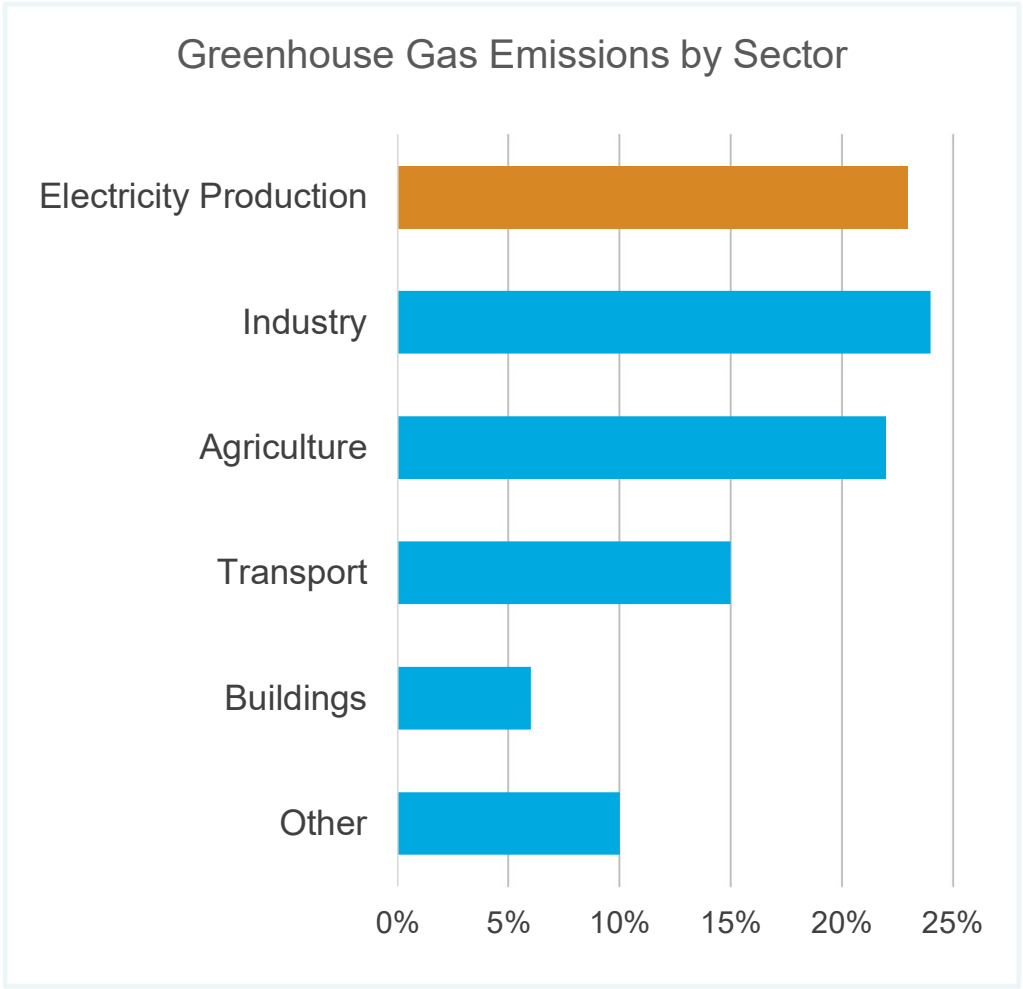
ENHANCING MODEL PREDICTIVE CONTROL OF A 3 MW WIND TURBINE WITH MACHINE LEARNING


Paul Piechnick, RWTH Aachen University


Andreas Klein, RWTH Aachen University


Jeffrey Stegink, W2E Wind to Energy GmbH


Greenhouse Gas Emissions by Sector
Electricity Production
Industry
Agriculture
Transport
Buildings
Other
0%
5%
10%
15%
20%
25%


Greenhouse Gas Emissions by Sector
Electricity Production
Industry
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Other
0%
5%
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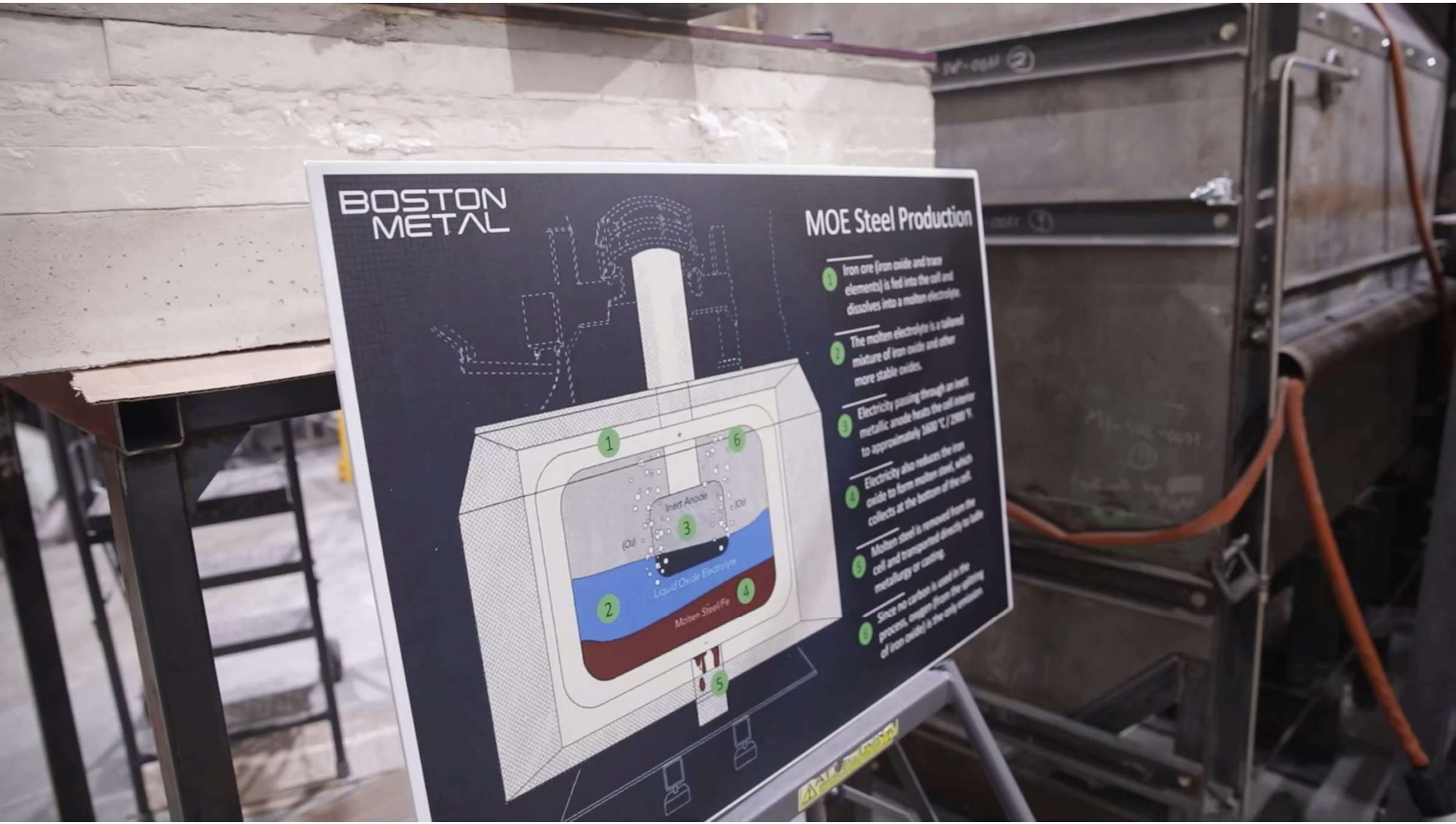
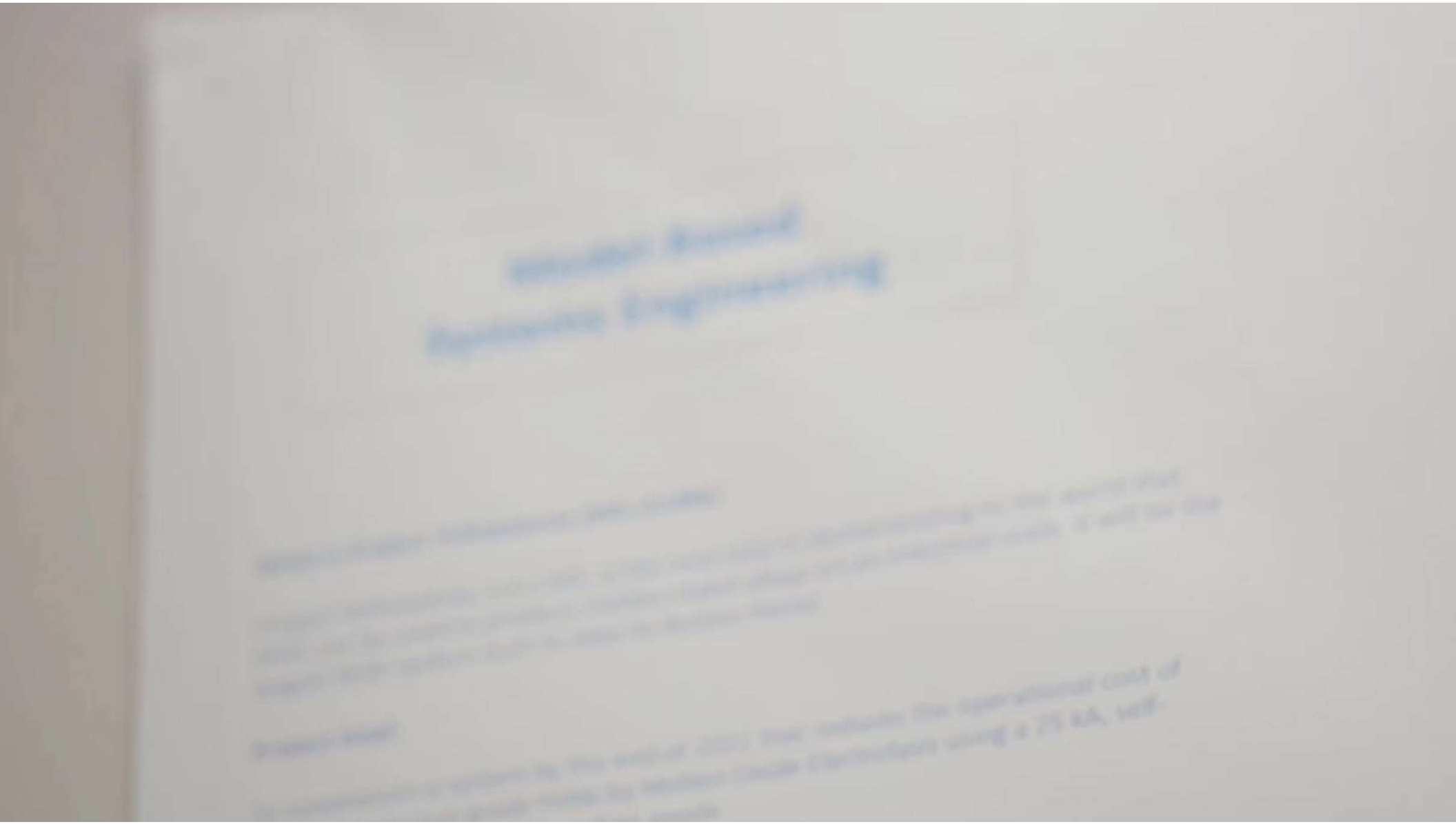
25%

Transforming the Steel Industry

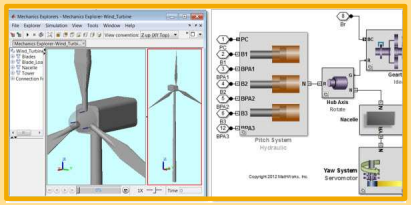

BOSTON METAL
MOE Steel Production
1 Iron ore (iron oxide and trace elements) is fed into the cell and dissolves into a molten electrolyte.
2 The molten electrolyte is a tailored mixture of iron oxide and other more stable oxides.
3 Electricity passing through an inert metallic anode heats the cell interior to approximately 1600 °C / 2900 °F.
4 Electricity also reduces the iron oxide to form molten steel, which collects at the bottom of the cell.
5 Molten steel is removed from the cell and transported directly to the metallurgy or casting.
6 Since no carbon is used in the process, oxygen (from the splitting of iron oxide) is the only emission.
Inert Anode
Liquid Oxide Electrolyte
Molten Steel/Fe
O2
O2



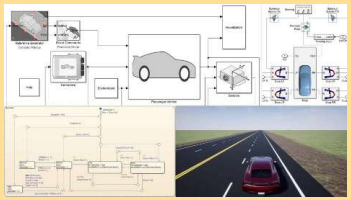
Transforming the Steel Industry

Design Solutions

Adjustable model with workflow tools to answer design questions

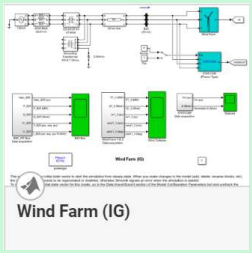


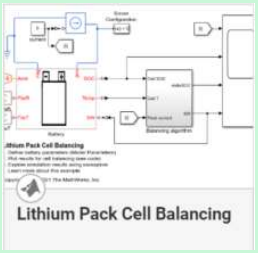
Simscape Battery R2022b

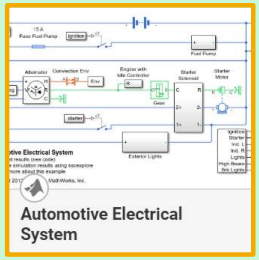


Reference Examples

Full system model to illustrate possibilities

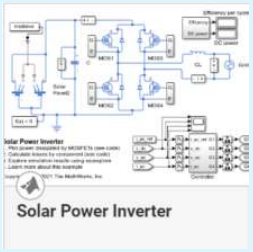


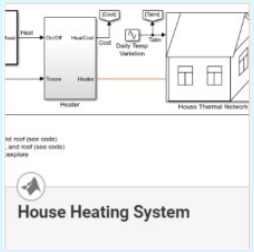


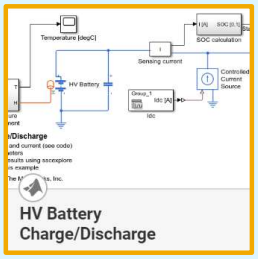


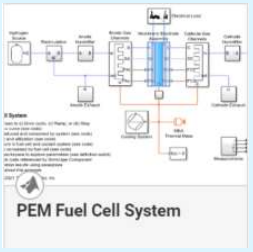
Component Examples

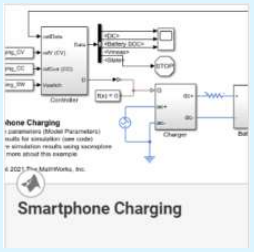
Demonstrate use of components in simulation





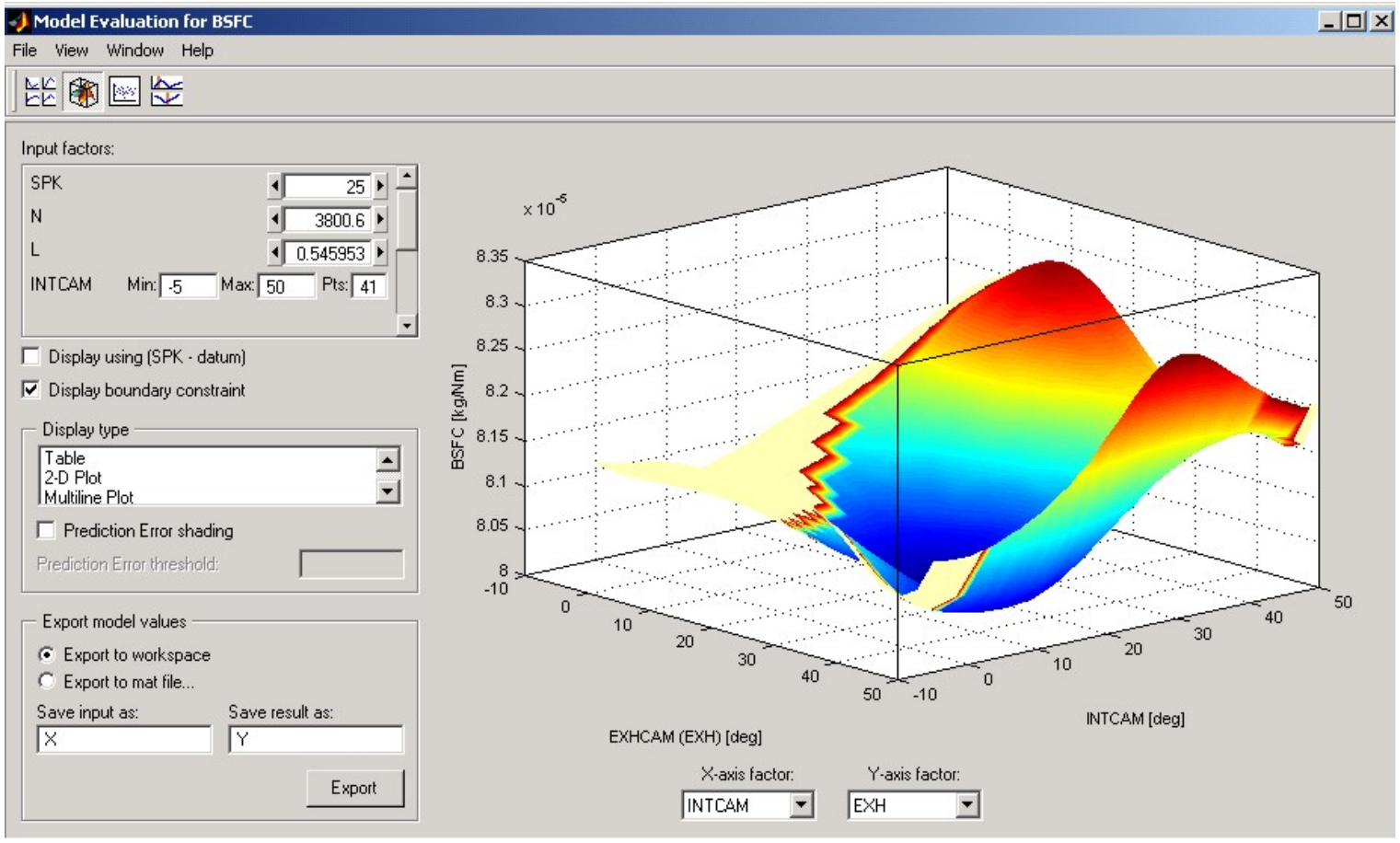




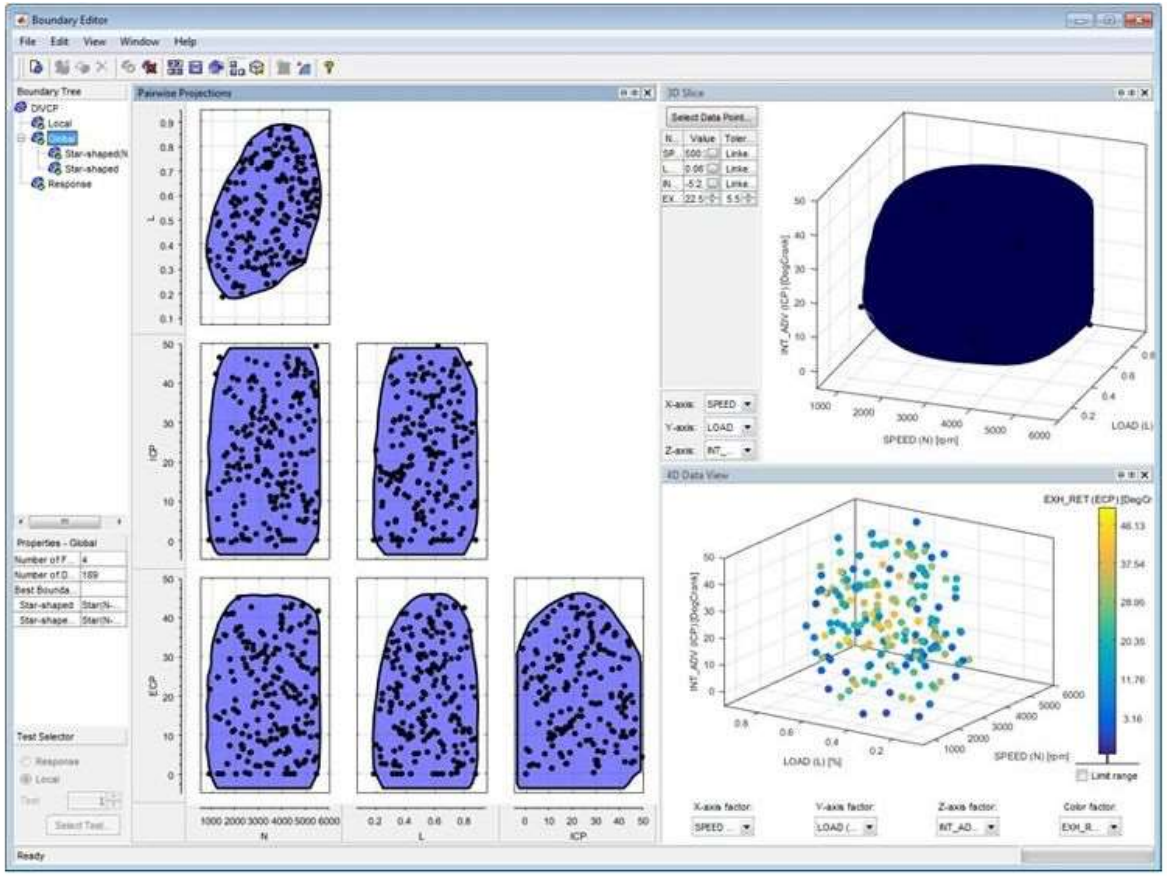


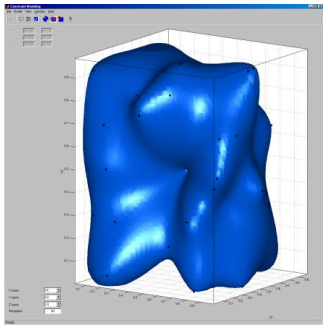

BOSTON
METAL
ENTRANCE

Application Example: Increasing fuel-efficiency of car engines with radial basis functions

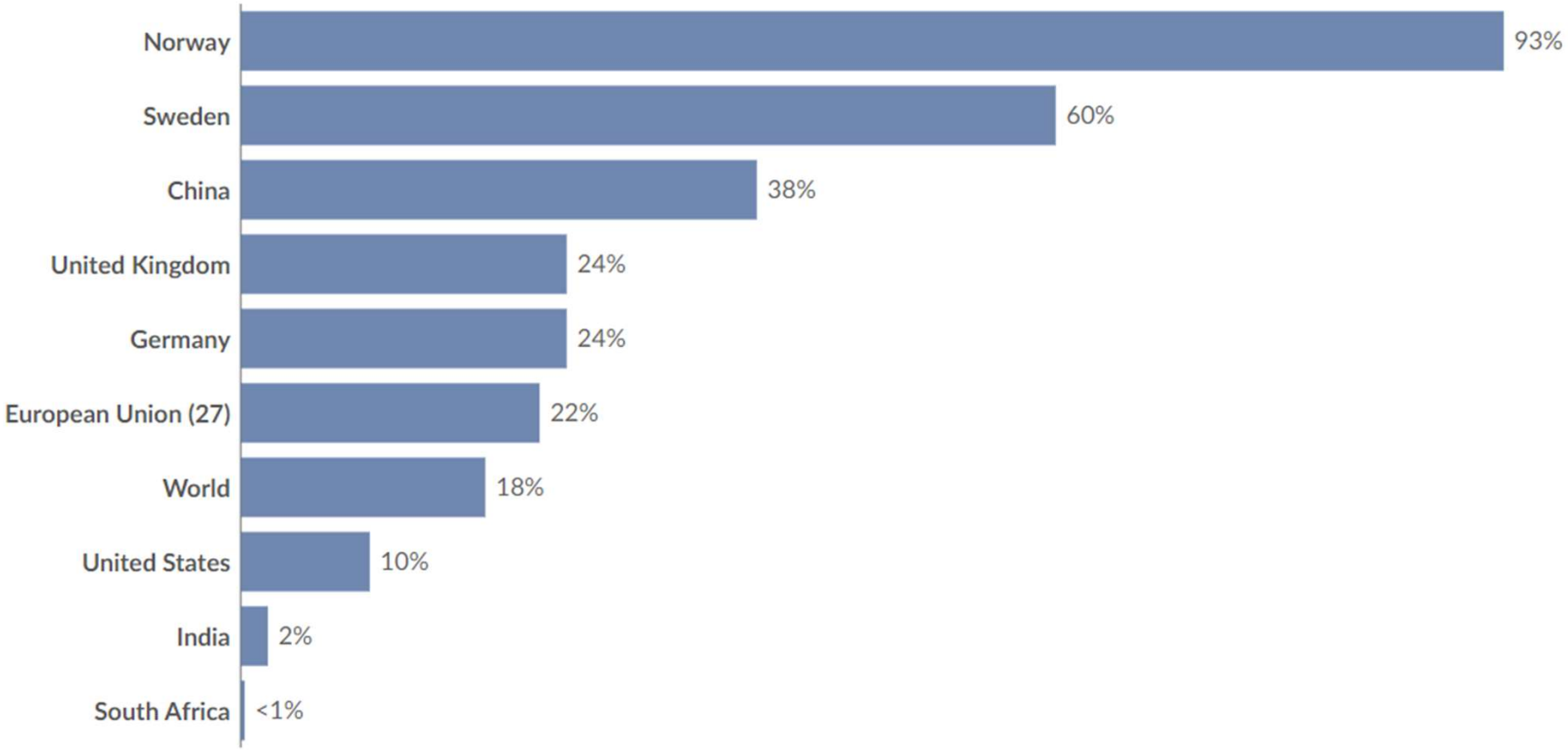


Using Spherical Basis Functions to define and visualize the feasible testing region of engines





Share of new cars sold that are electric, 2023



Data source: International Energy Agency. Global EV Outlook 2024.

OurWorldinData.org/energy | CC BY

Hands-On Workshop

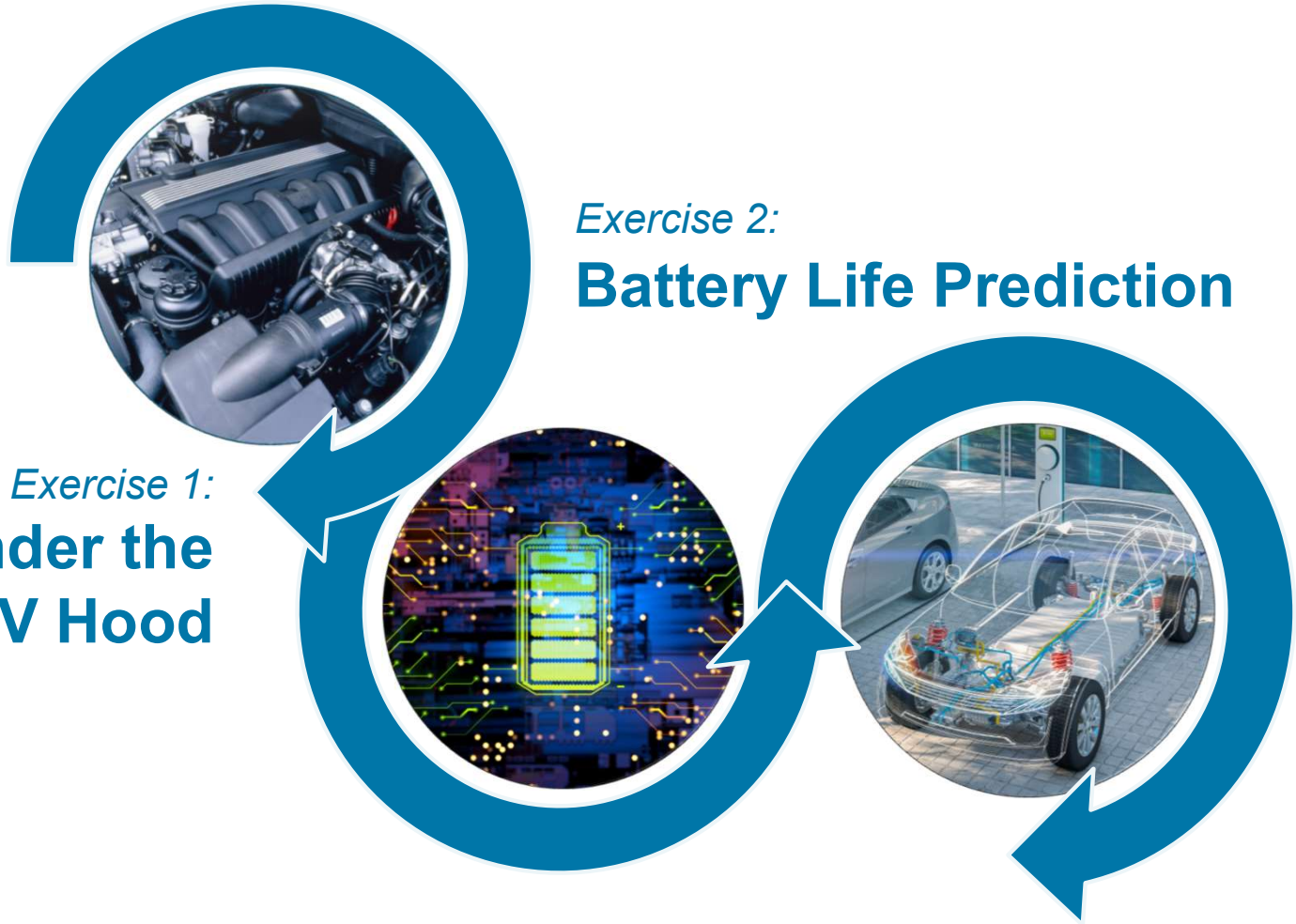
FIND OUT MORE

WATT'S UP WITH ELECTRIC VEHICLES: MODELLING THE EV ECOSYSTEM

Eva Pelster, MathWorks

Nayara Aguiar, MathWorks

Tanya Morton, MathWorks



Exercise 1:
Under the EV Hood

Exercise 2:
Battery Life Prediction

Exercise 3:
Smart Charging

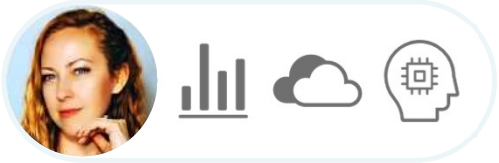
AI and Electrification

FIND OUT MORE

IMPLEMENTATION OF A PROBALISTIC POWER FLOW SYSTEM

John Kreso III, Eversource Energy

Steffen Ziegler, Eversource Energy



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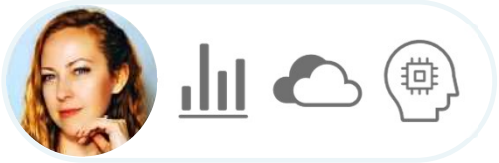
Industry

Electrify Everything



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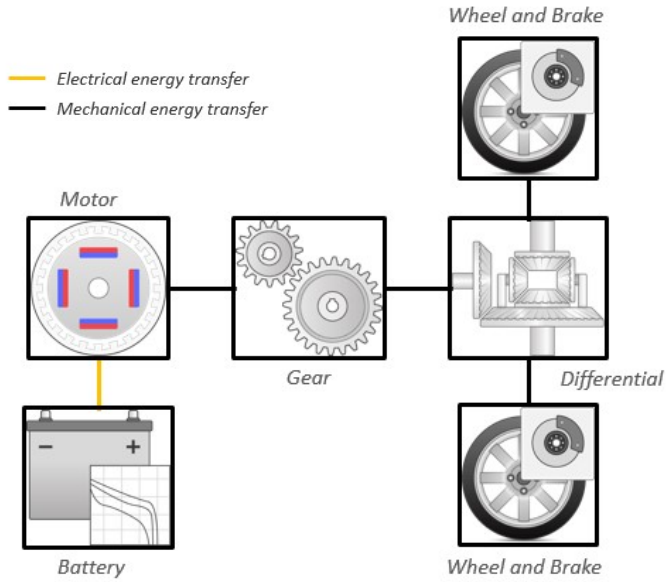
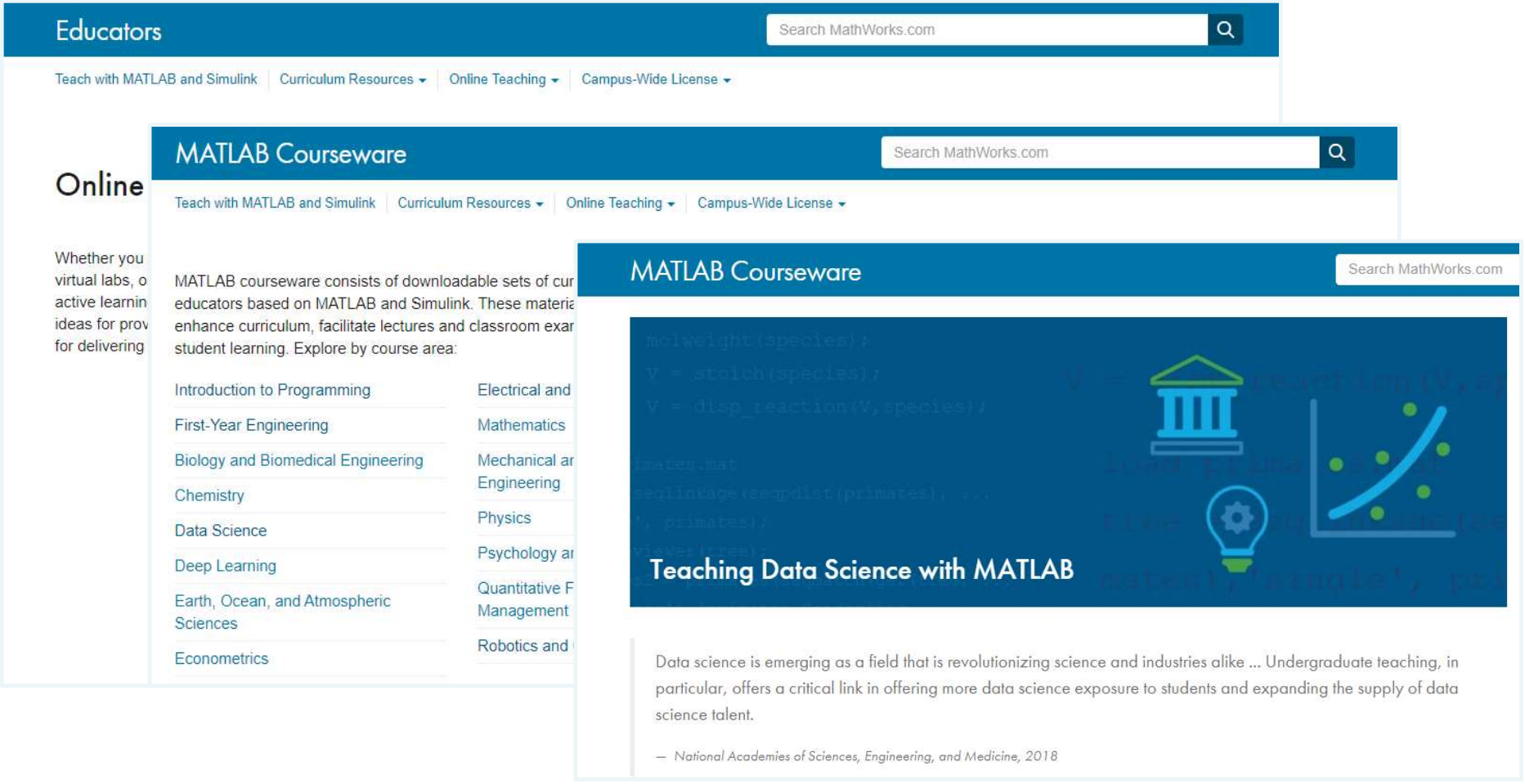
Curriculum Development

Electric Vehicle Fundamentals



> “The EVSE course I took in my final year of BTech was a turning point in my understanding of the world of engineering.”

—Hari Bhaskar, Bosch Global Software Technologies and Graduate of NIT Calicut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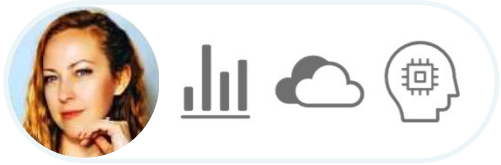
— National Academies of Sciences, Engineering, and Medicine, 2018



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Student Research

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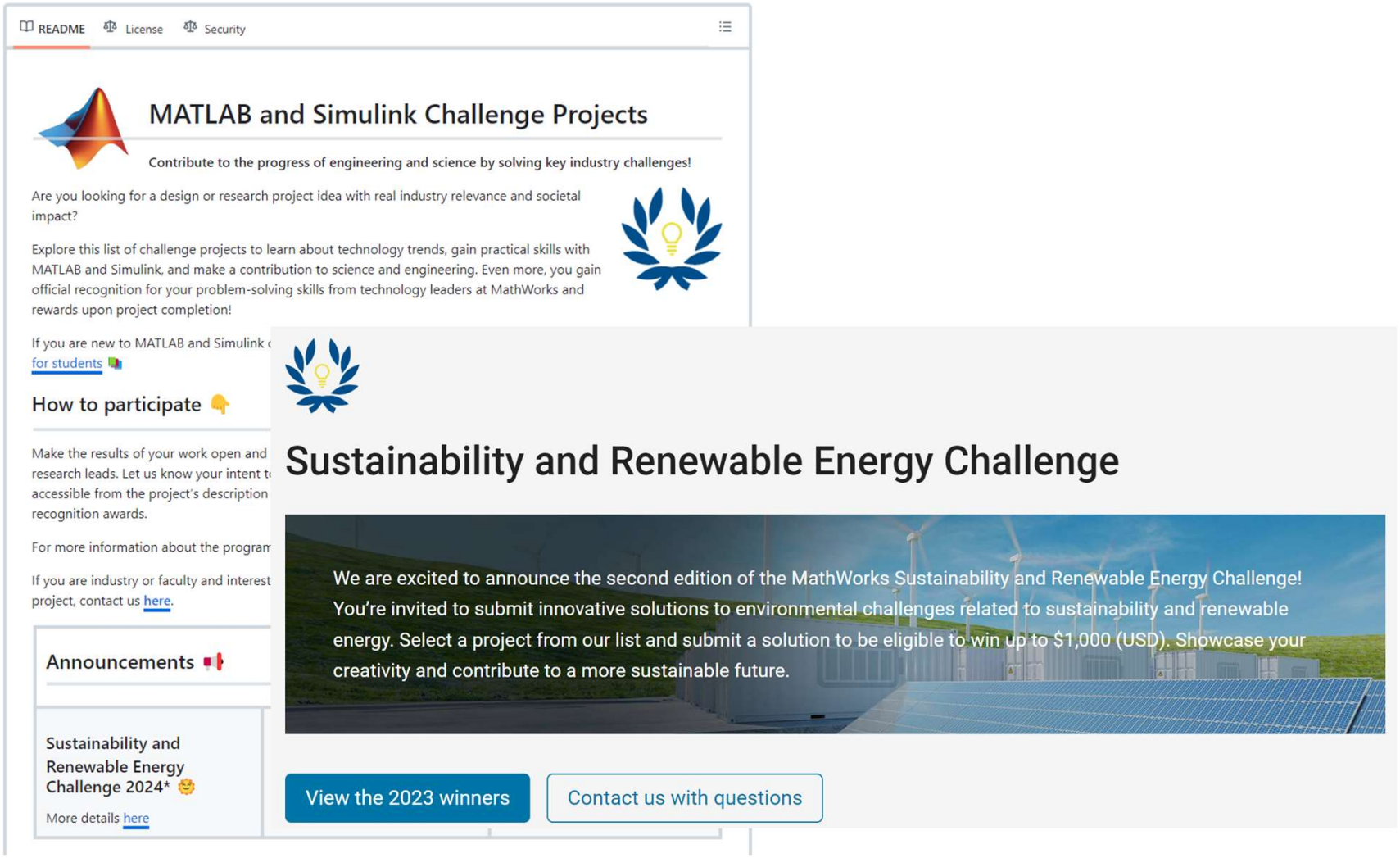
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More details here
Sustainability and Renewable Energy Challenge
We are excited to announce the second edition of the MathWorks Sustainability and Renewable Energy Challenge! You're invited to submit innovative solutions to environmental challenges related to sustainability and renewable energy. Select a project from our list and submit a solution to be eligible to win up to $1,000 (USD). Showcase your creativity and contribute to a more sustainable future.
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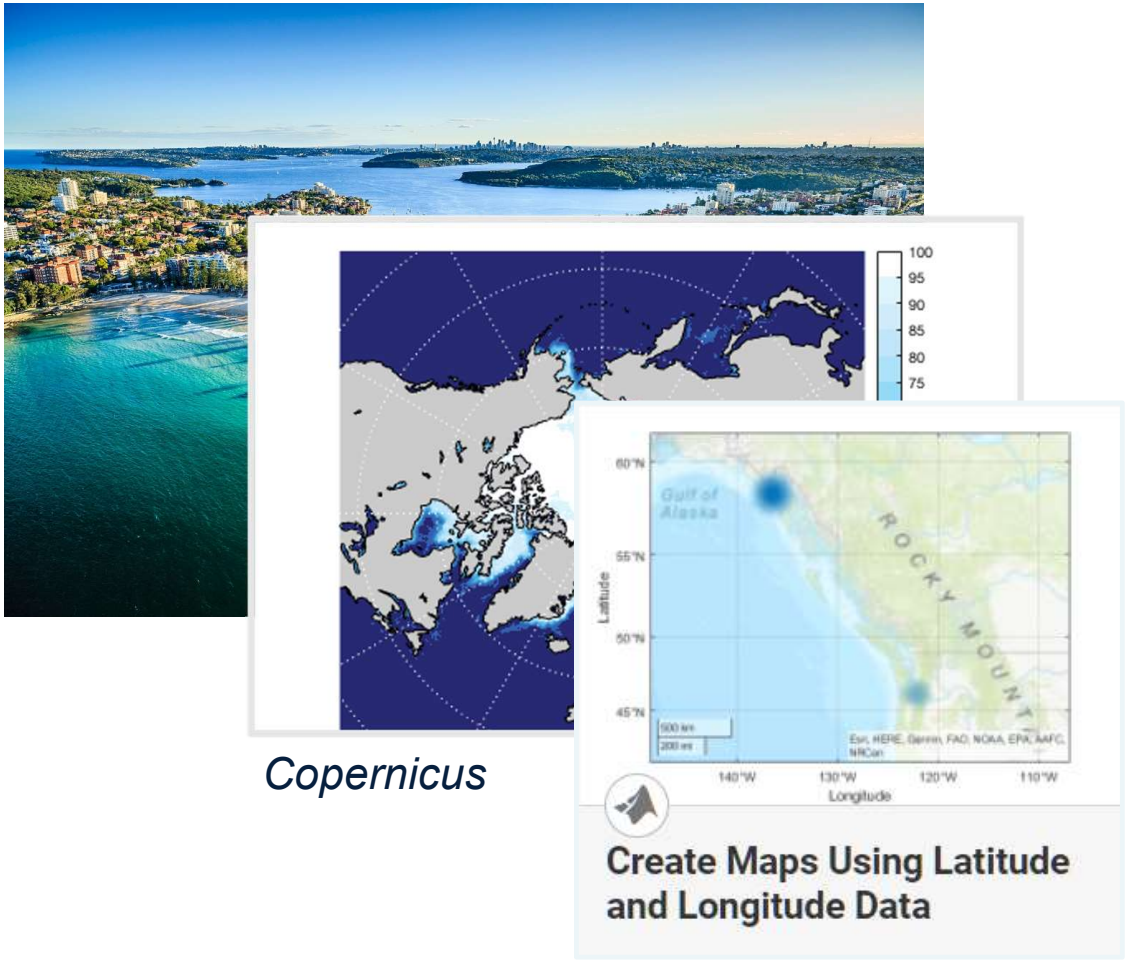
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Longitude
Gulf of Alaska
ROCKY MOUNTA
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THE EMPATHETIC ENGINEERS OF TOMORROW

Dr. Darryll Pines, University of Maryland

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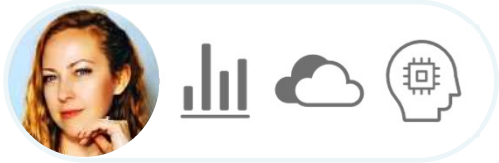

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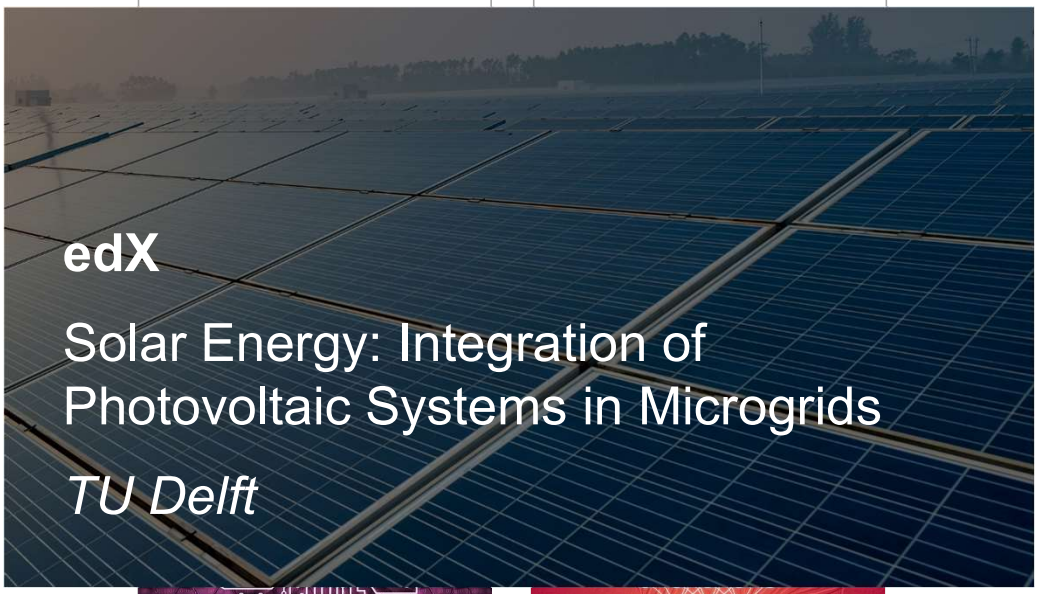
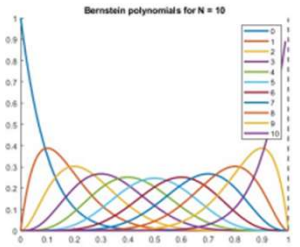


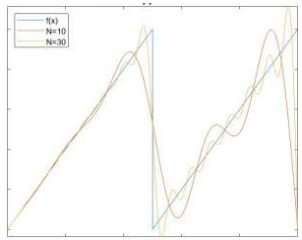
Machine Learning with MATLAB

Deep Learning with MATLAB

And more...

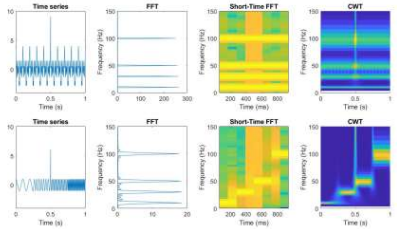
Approximation Techniques with MATLAB





Function approximation

- Uniform approximation (Bernstein, Bezier)
- L^2-approximation with orthogonal polynomials (Jacobi, Fourier)

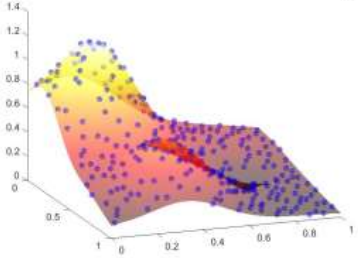


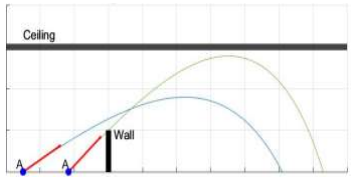
Wavelets Analysis in $L^2(R)$

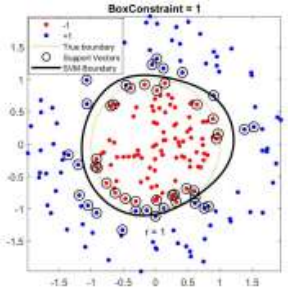
- Wavelet Transform
- Multiresolution Analysis

Radial Basis Functions

- Scattered data interpolation
- Surrogate Global Optimization
- Kernelized Support Vector Machines

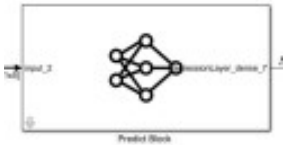




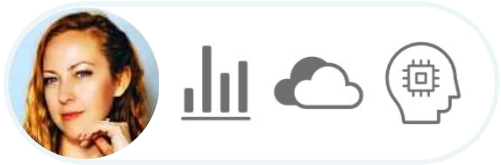


Neural Networks

- Universal approximators
- Approximation of an Extended Kalman Filter.



[Approximation Techniques with MATLAB® | Dolomites Research Notes on Approximation](), Paolo Panarese, MathWorks



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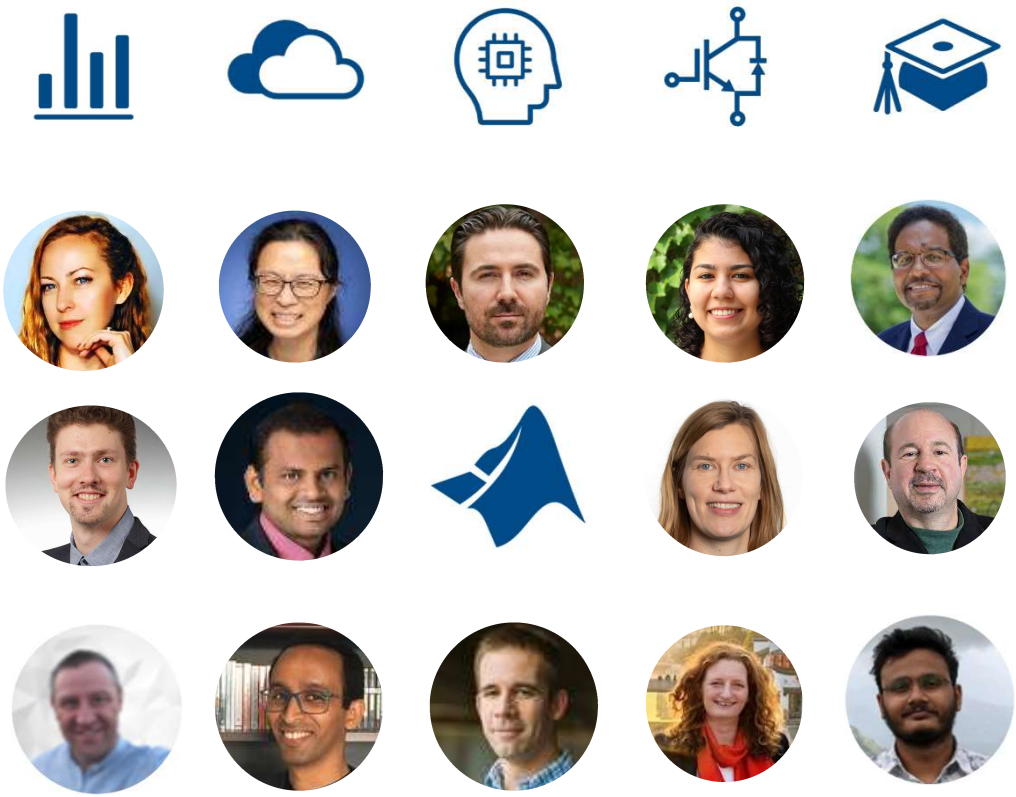

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