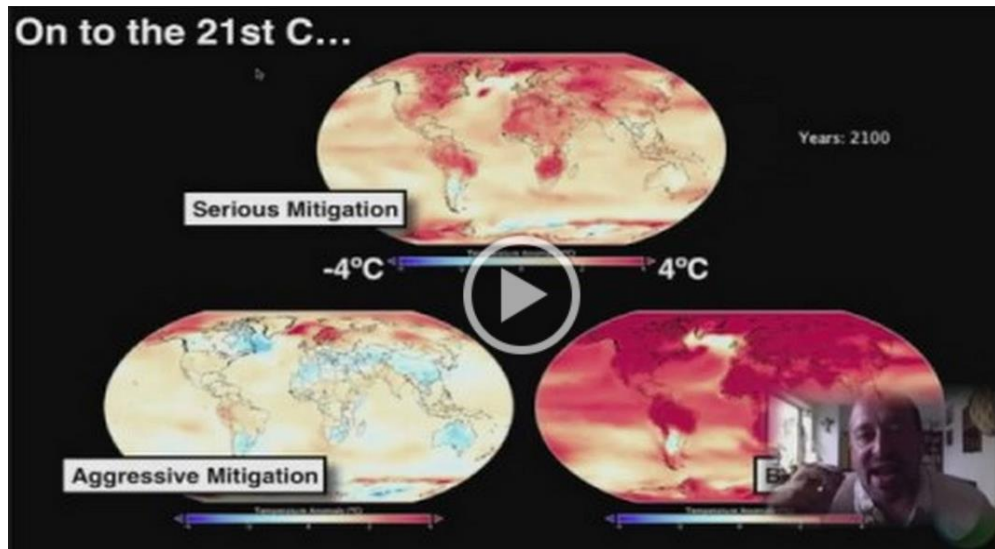
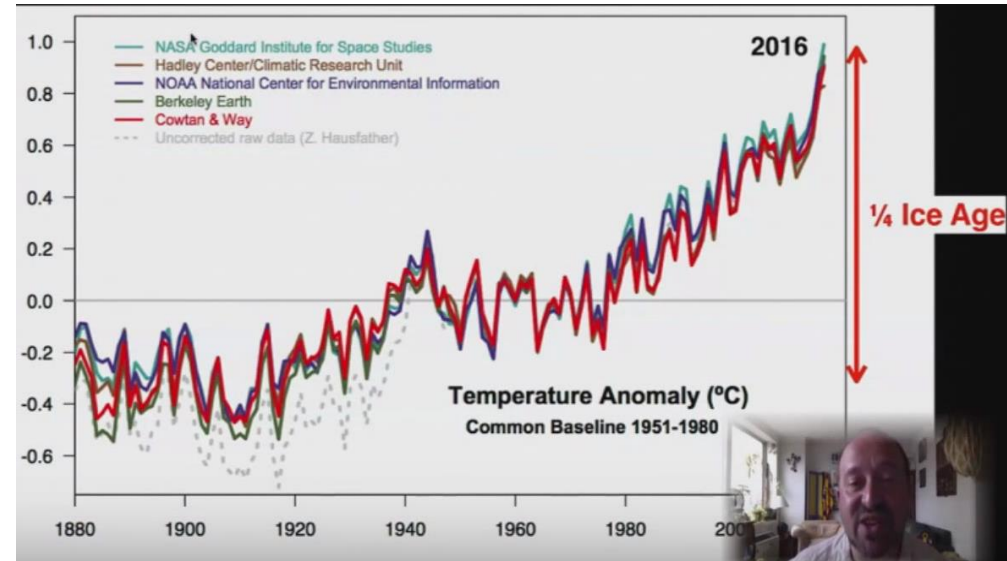
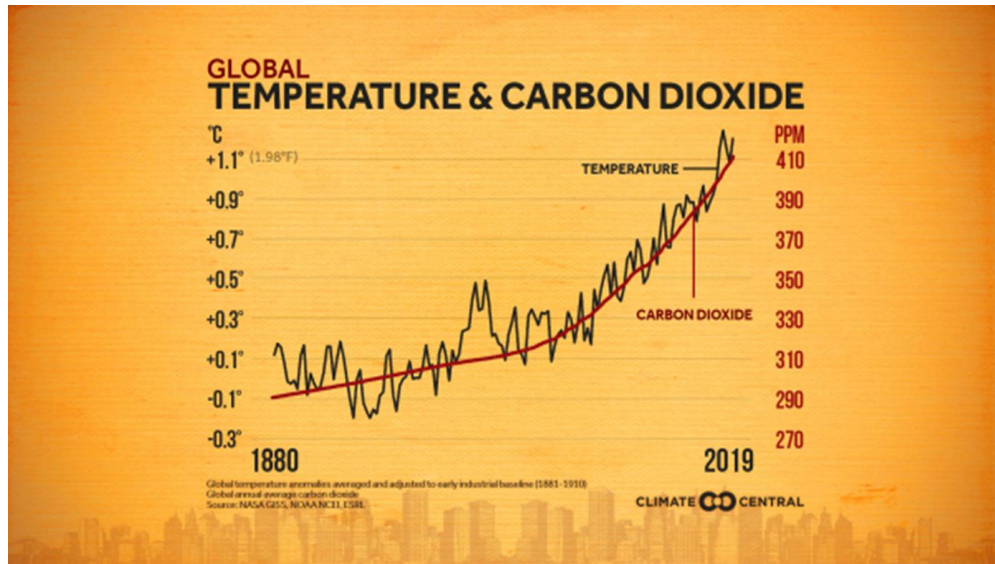


Building A Robust Workforce in Electric Power Engineering by Democratizing Technical Education



Ned Mohan (mohan@umn.edu)
Siddharth Raju (raju@umn.edu)

Climate Crisis: An Existential Threat



So, the answer (?) is.....

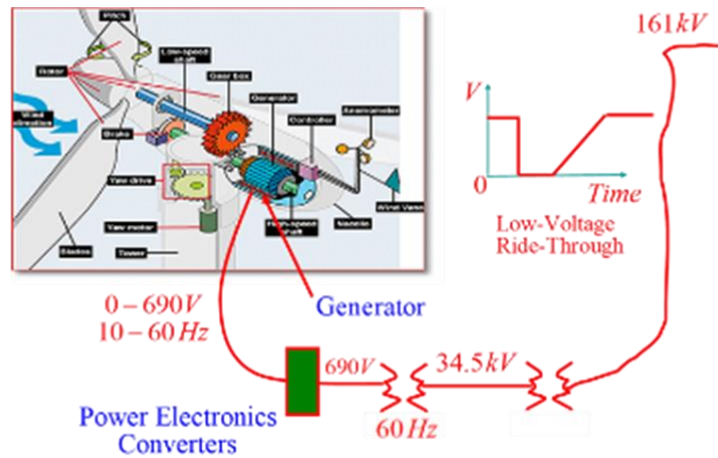
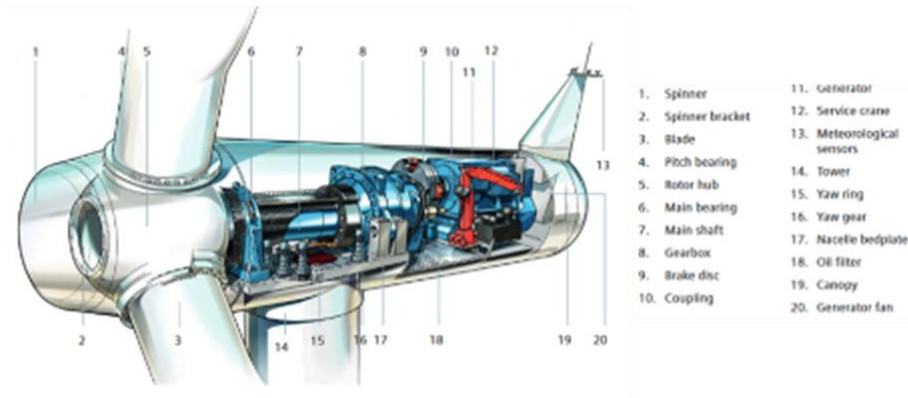
Electrify Everything

- Shift all our Energy Use to Electricity
- Generate Electricity from Renewables
- Conservation
- Sustainability Mindset

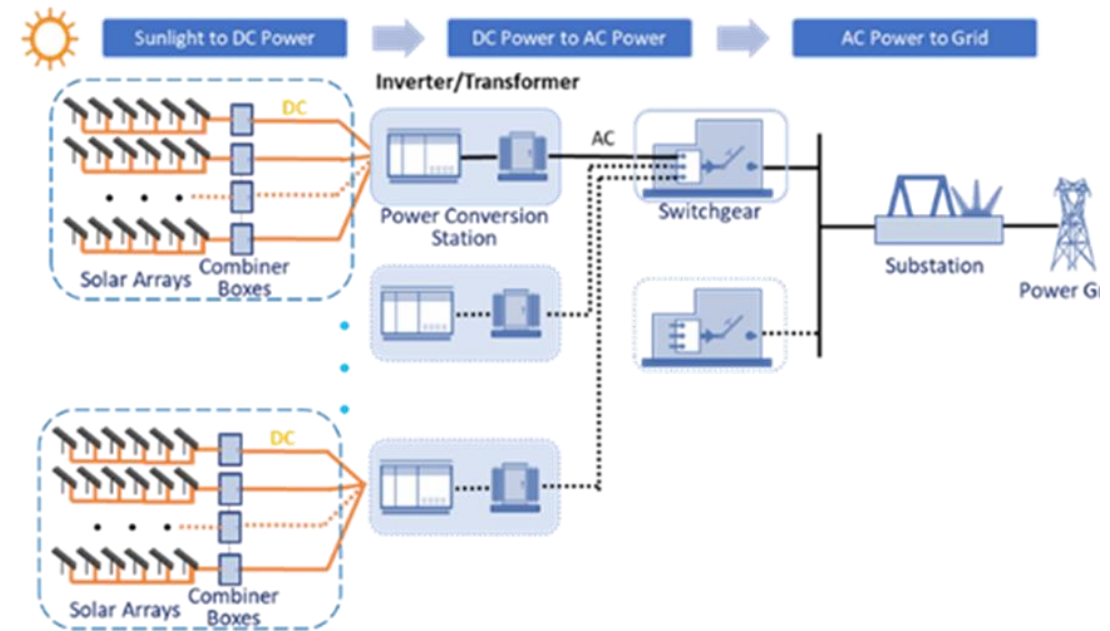
Goal: Net-Zero by 2050

- Massive Deployment of Wind and solar

Energy from the Wind



Energy from the Sun



If you care about climate change, you should care about this

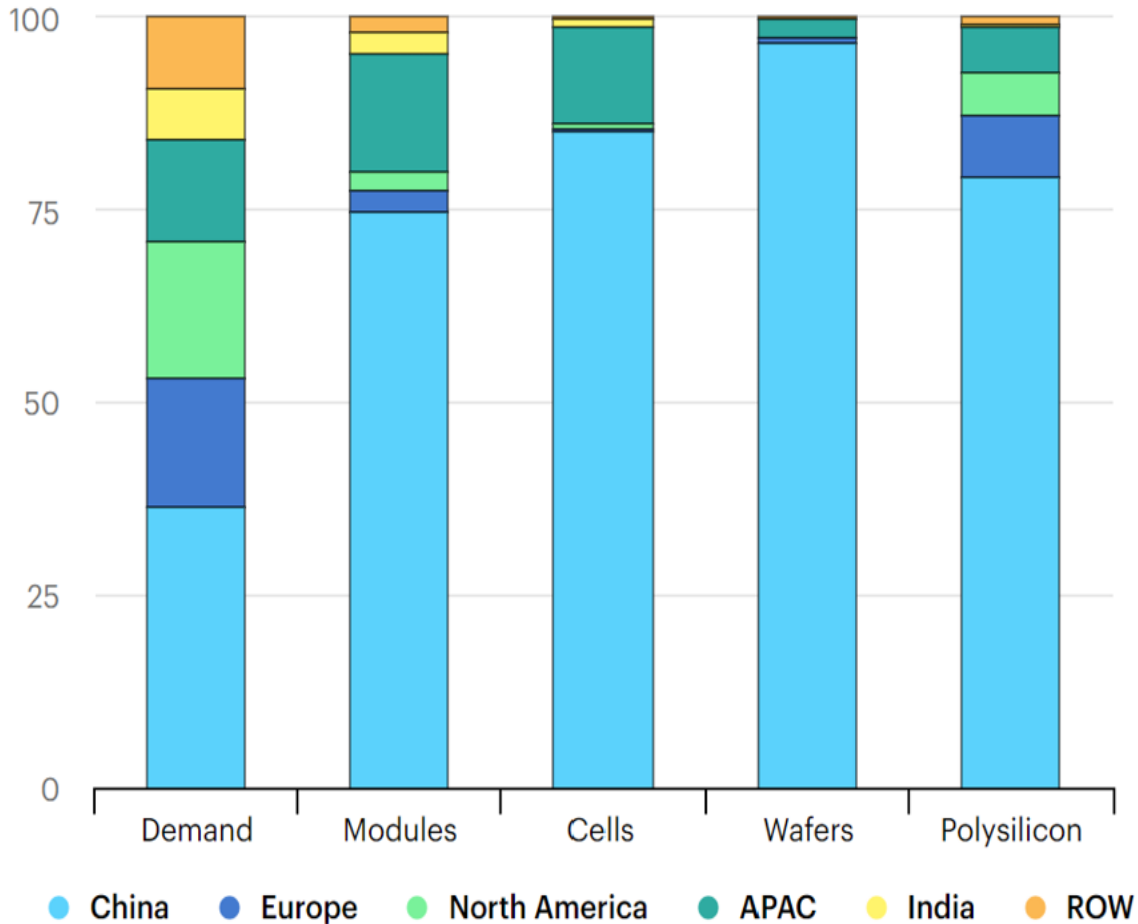


By **Bill Gates** | January 24, 2023

[The surprising key to a clean energy future | Bill Gates \(gatesnotes.com\)](https://gatesnotes.com)

Made in the USA?

Solar PV manufacturing capacity by country and region, 2021



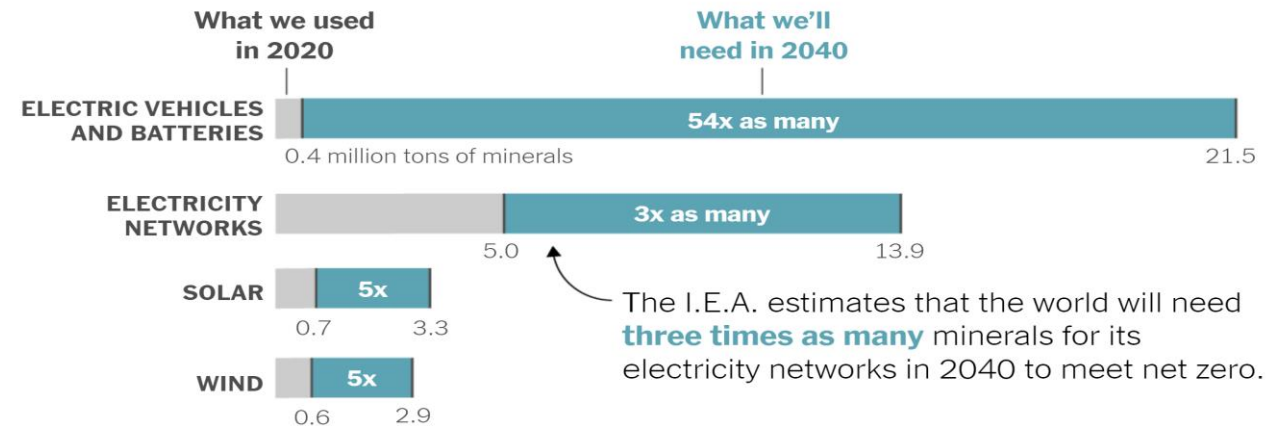
Source: "Solar PV Global Supply Chains," IEA



Challenges

To bring carbon emissions to net zero, the world needs significantly more minerals

Global demand for minerals like copper, nickel, lithium and graphite, by type of clean energy



Source: International Energy Agency

How “clean” are Renewables?



Coal

~1000 g CO₂eq/kWh



Wind

~10 g CO₂eq/kWh

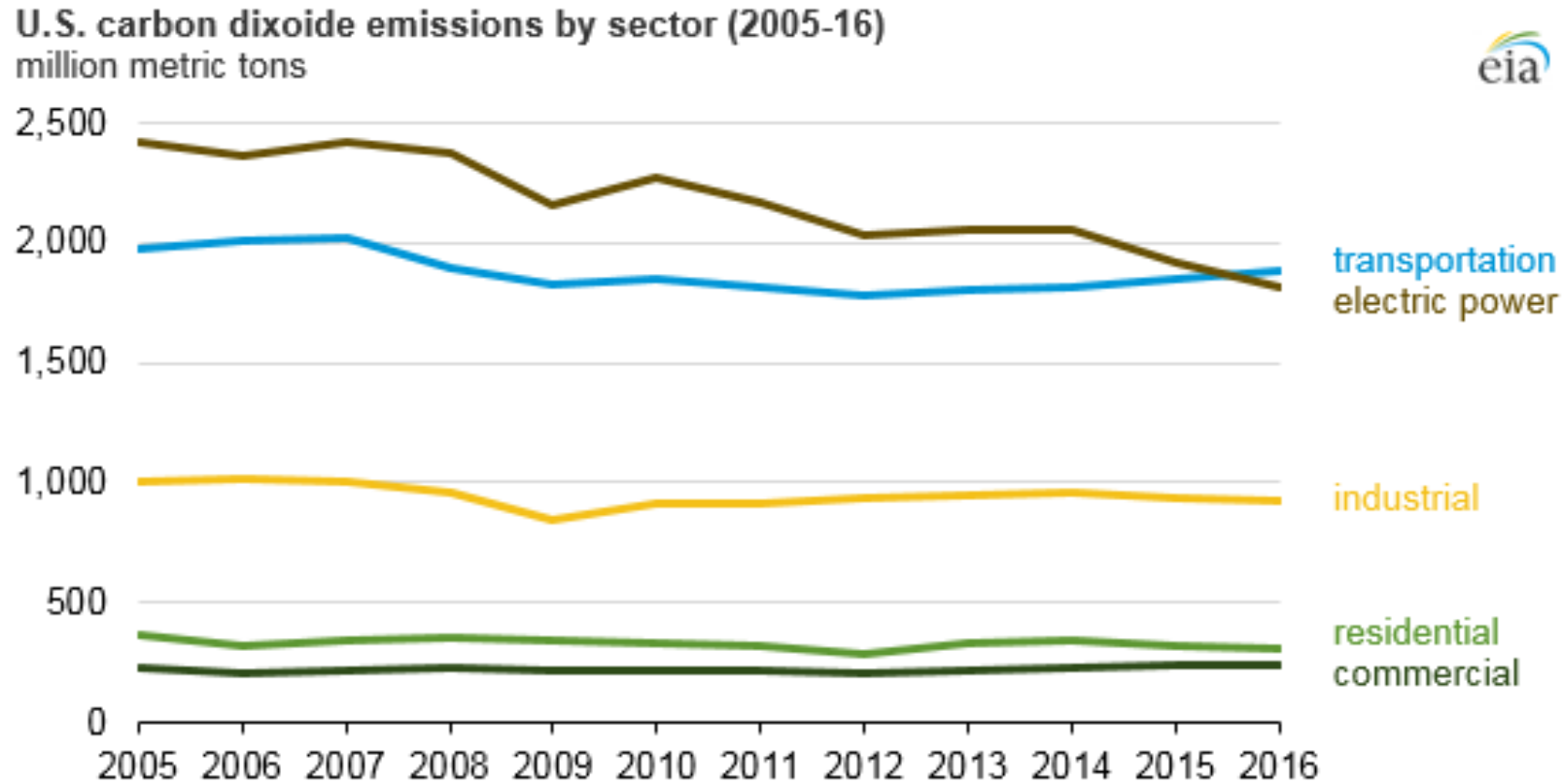
Photovoltaics (PV)



~40 g CO₂eq/kWh

- Wind 100 times cleaner
- Solar 25 times cleaner

Transitioning to EVs:



Transitioning to EVs:

California bans the sale of new gas-powered cars by 2035



Ford laying off 3,000 employees to cut costs, pay for EV transition



Need for Retraining: Thousands of auto-mechanics will become unemployed

Climate Refugees

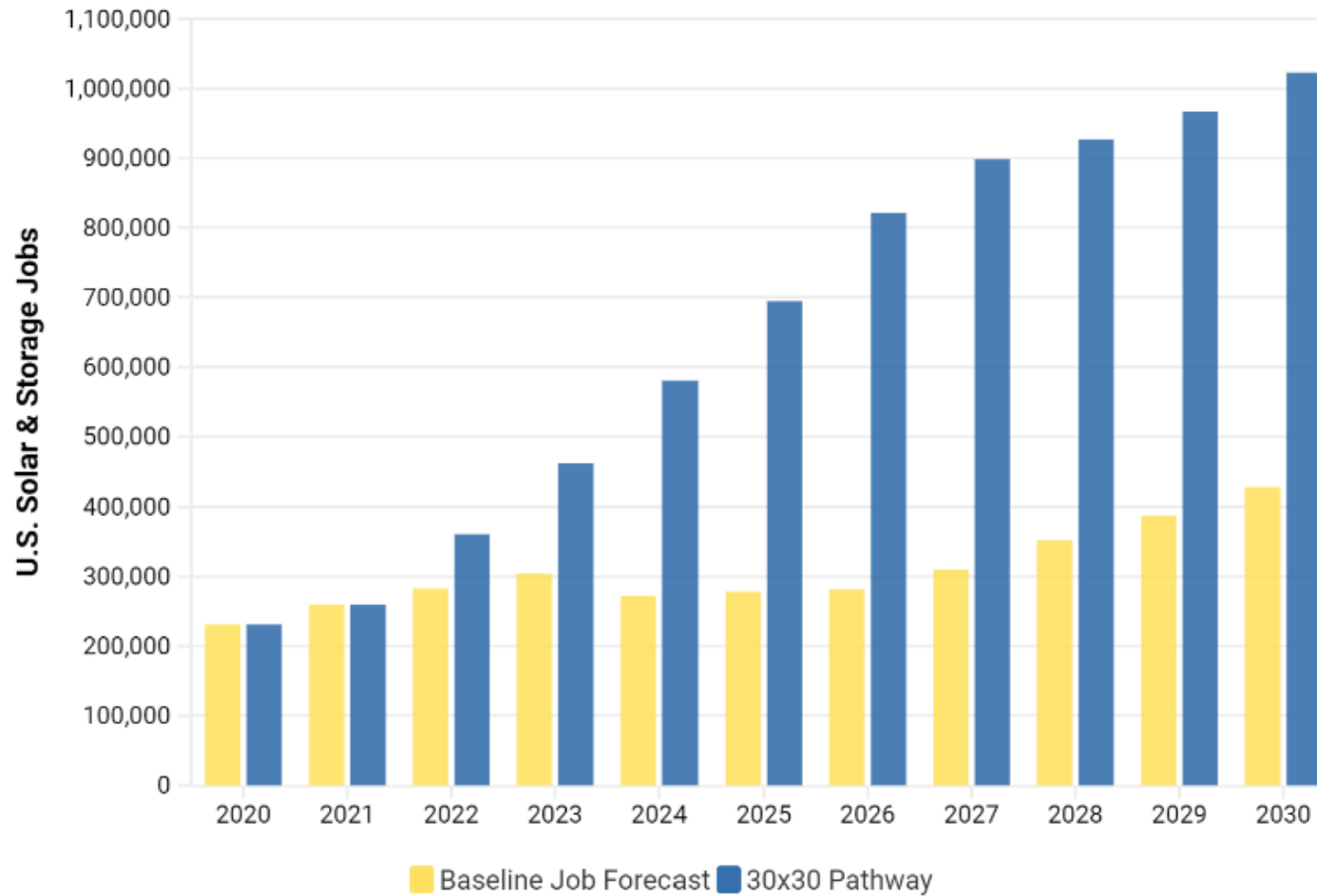
One-third of Mideast refugees are from Syria, Iraq, and Afghanistan; two-thirds are from a cluster of very arid African countries.



Refugee children sent north by their parents from Guatemala, Honduras, and El Salvador are from the most environmentally degraded and deforested areas in Central America.

Need for Engineers:

Reaching 30% of Generation will Require 1 Million U.S. Jobs



Sources: [SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight Report 2021 Q3](#), [SEIA 30x30 Analysis](#)



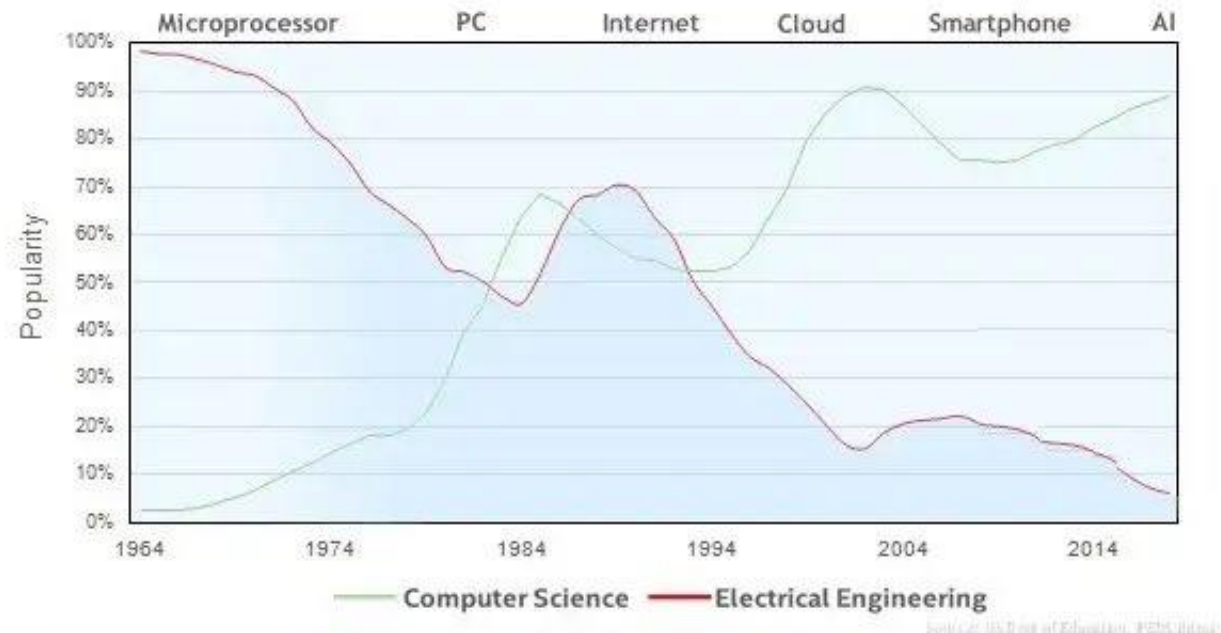
Sharply Declining College Enrollments

What first looked like a [pandemic blip](#) has turned into a crisis. Nationwide, undergraduate college enrollment dropped 8% from 2019 to 2022, with declines even after [returning to in-person classes](#), according to data from the National Student Clearinghouse. The slide in the college-going rate since 2018 is the steepest on record, according to the U.S. Bureau of Labor Statistics.

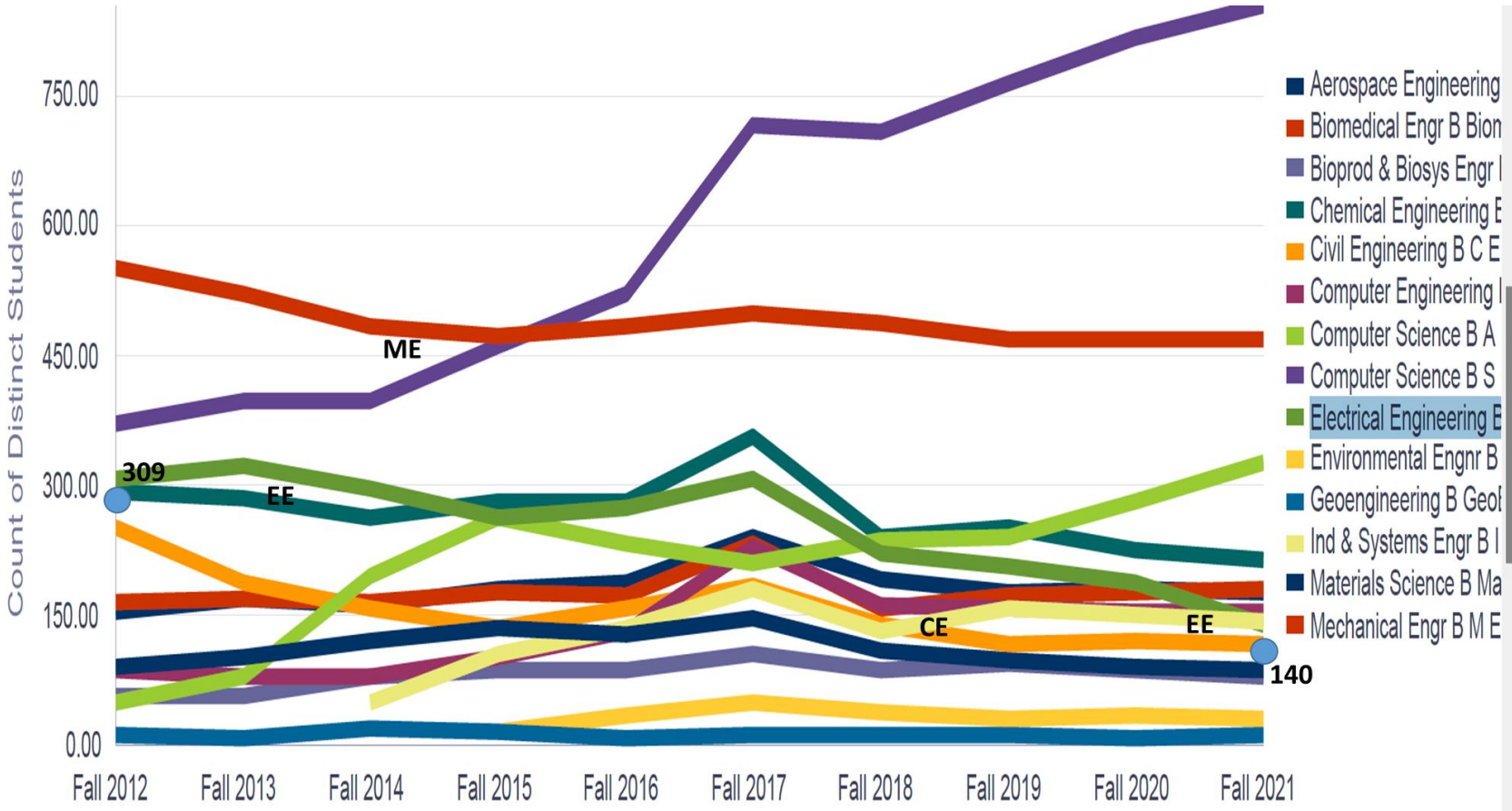
Fewer college graduates could worsen [labor shortages](#) in fields from health care to information technology. For those who forgo college, it usually means lower lifetime earnings — 75% less compared with those who get bachelor's degrees, according to Georgetown University's Center on Education and the Workforce. And when the economy sours, those without degrees are more likely to lose jobs.

Sharply Declining Enrollments in EE

College Enrollment : EE vs CS



Sharply Declining Enrollments in EE

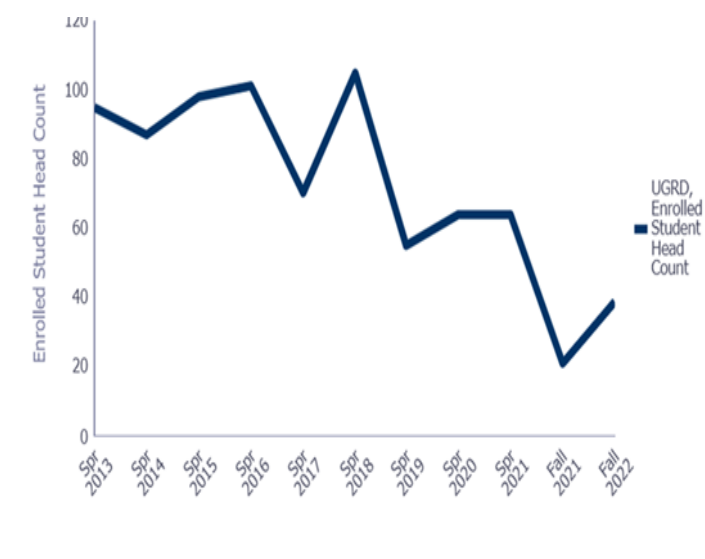


Sharply Declining Enrollments in EE

Power Systems



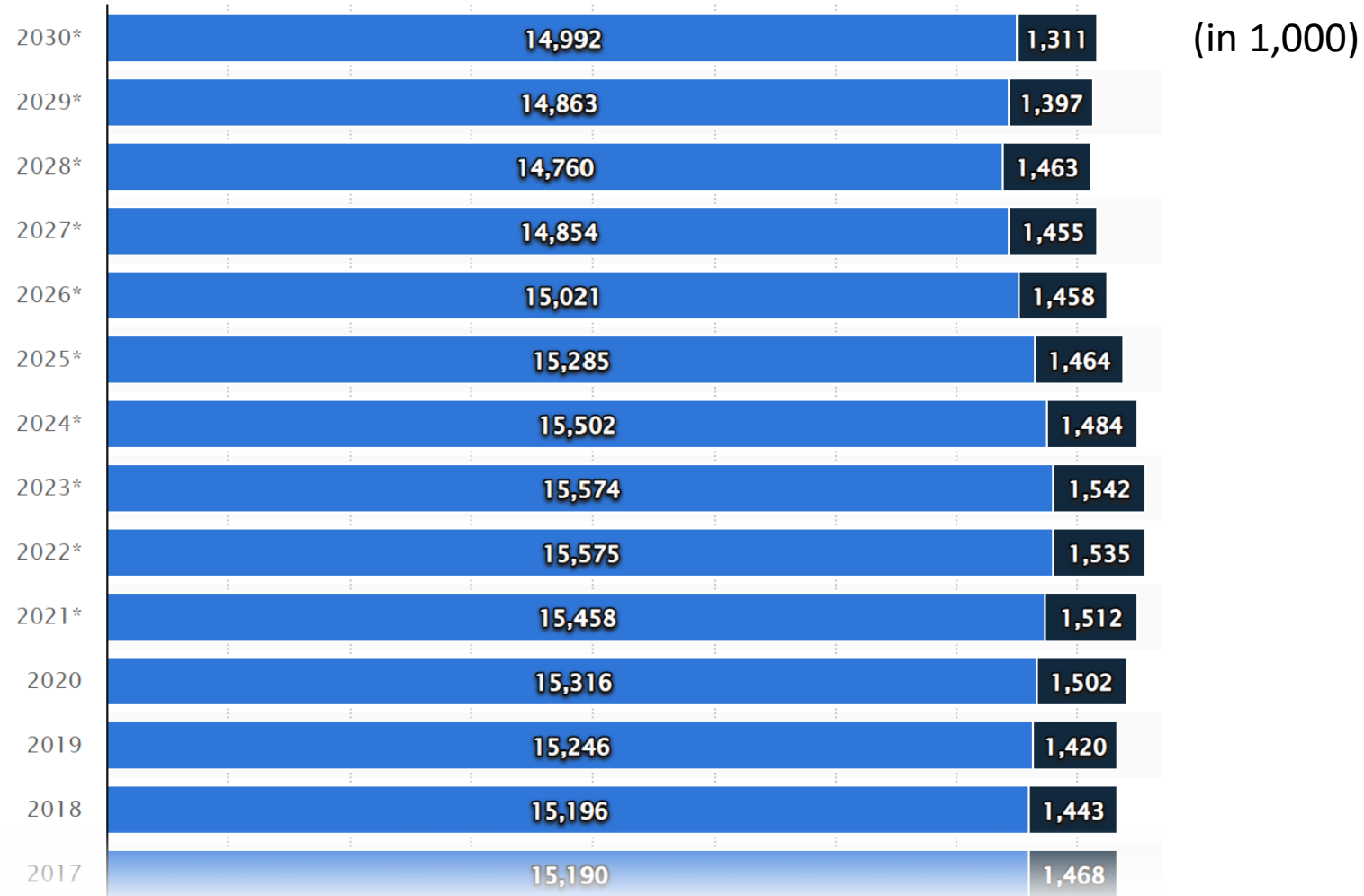
Electric Drives



Power Electronics



High school enrollment for public and private schools in the U.S. from 1965 to 2020, with projections up to 2029



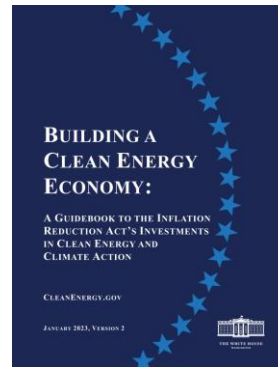
Once in a generation Opportunity



Speaker Pelosi Holds San Francisco Event on the CHIPS and Science. 57 Billion dollars in funding; 200 Million dollars for workforce development.

What's in the Inflation Reduction Act?

Policy/Provision	Cost (-)/Savings (2022-2031)
Energy and Climate	-\$386 billion
Clean Electricity Tax Credits	-\$161 billion
Air Pollution, Hazardous Materials, Transportation and Infrastructure	-\$40 billion
Individual Clean Energy Incentives	-\$37 billion
Clean Manufacturing Tax Credits	-\$37 billion
Clean Fuel and Vehicle Tax Credits	-\$36 billion
Conservation, Rural Development, Forestry	-\$35 billion
Building Efficiency, Electrification, Transmission, Industrial, DOE Grants and Loans	-\$27 billion
Other Energy and Climate Spending	-\$14 billion

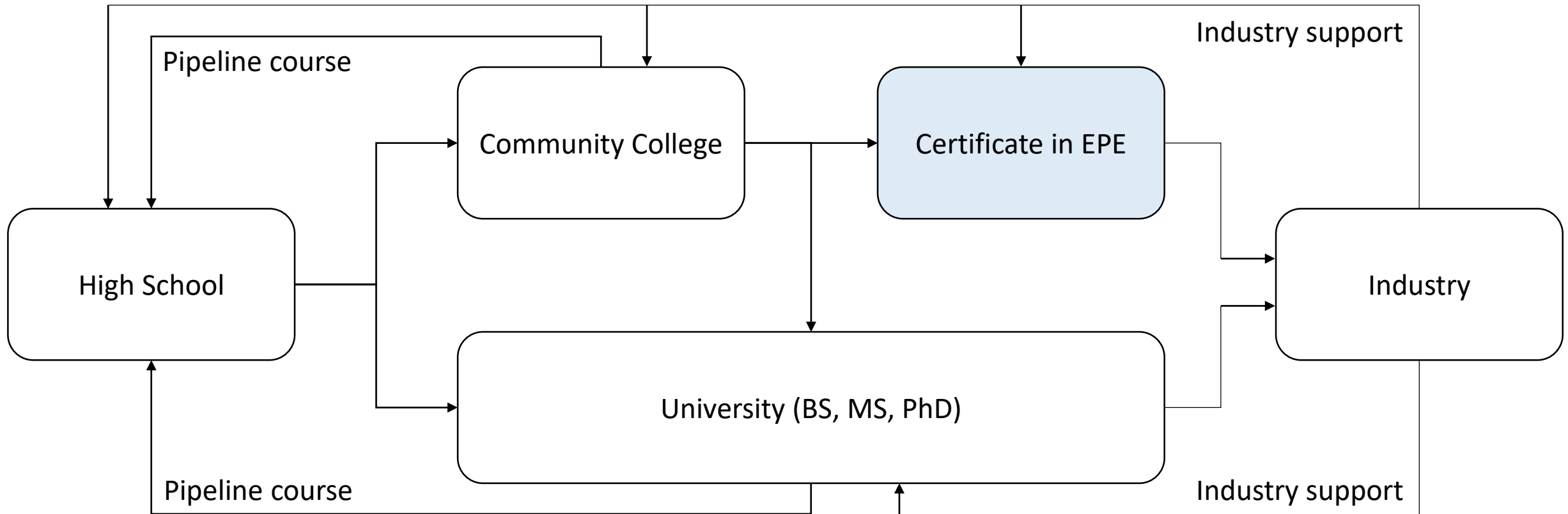


Everything In The \$1.2 Trillion Infrastructure Bill: New Roads, Electric School Buses And More

Electric grid and energy: Though many clean-energy measures were cut from the bill to satisfy spending-weary lawmakers, a \$108 billion investment will help upgrade the nation's electricity grid, with thousands of miles of new transmission lines and funds for environmentally friendly smart-grid technology.

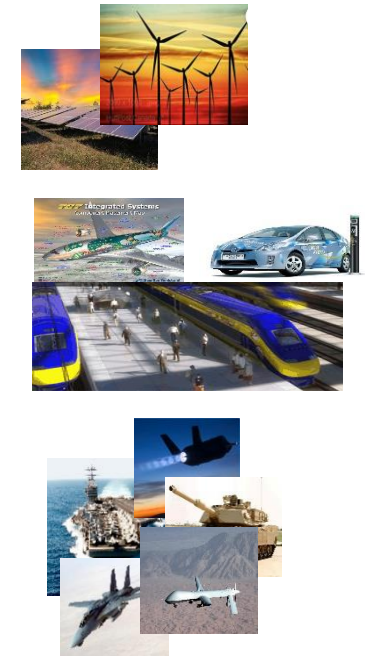
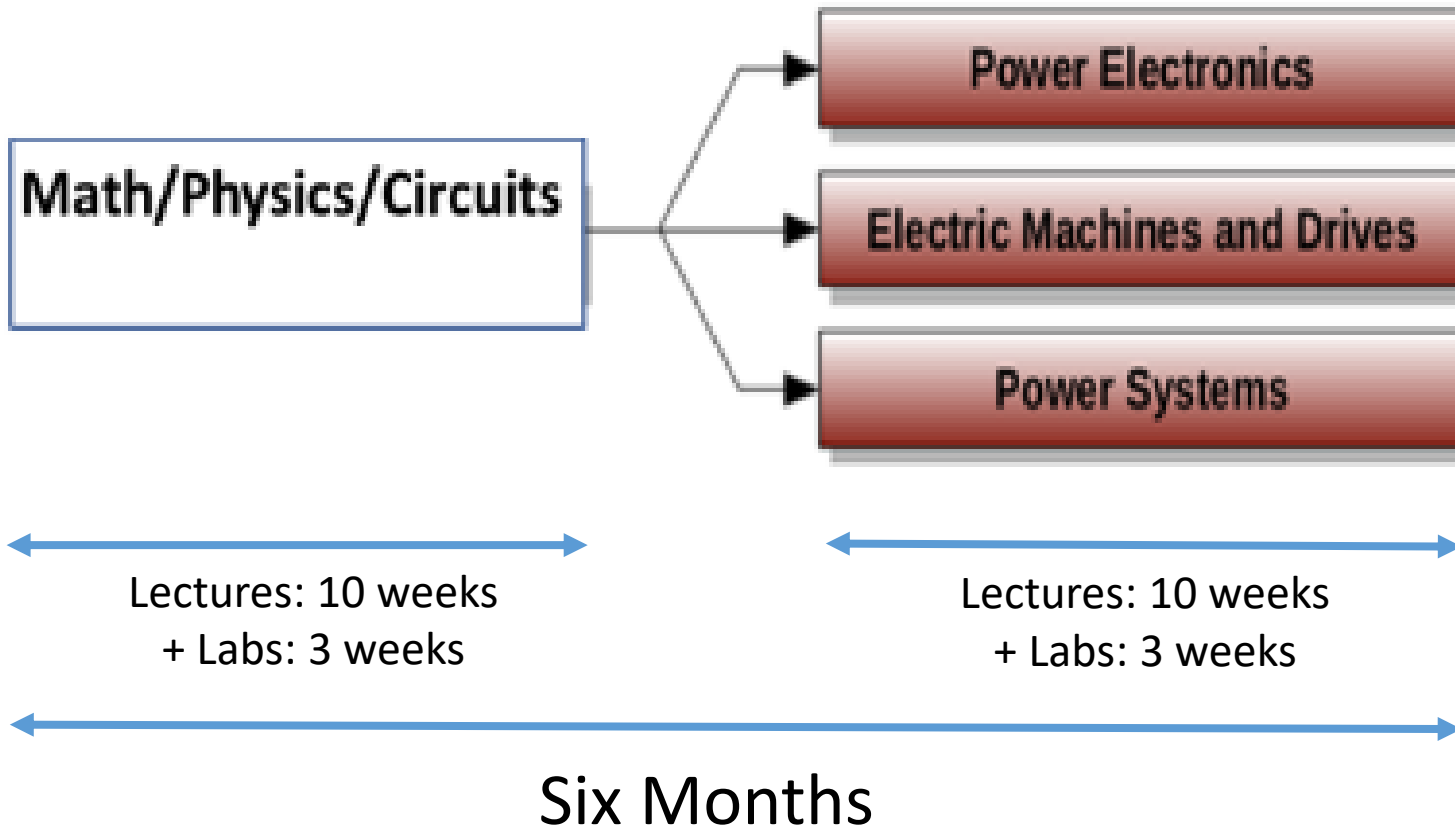
Electric cars, buses and ferries: In addition to \$7.5 billion for the nation's first network of electric-vehicle chargers along highway corridors, lawmakers have shored up \$5 billion for zero-emission buses (including thousands of electric school buses) and \$2.5 billion for ferries.

Proposed Solution: Multiple Pathways



A New Pathway: A Certificate in Electric Power Engineering

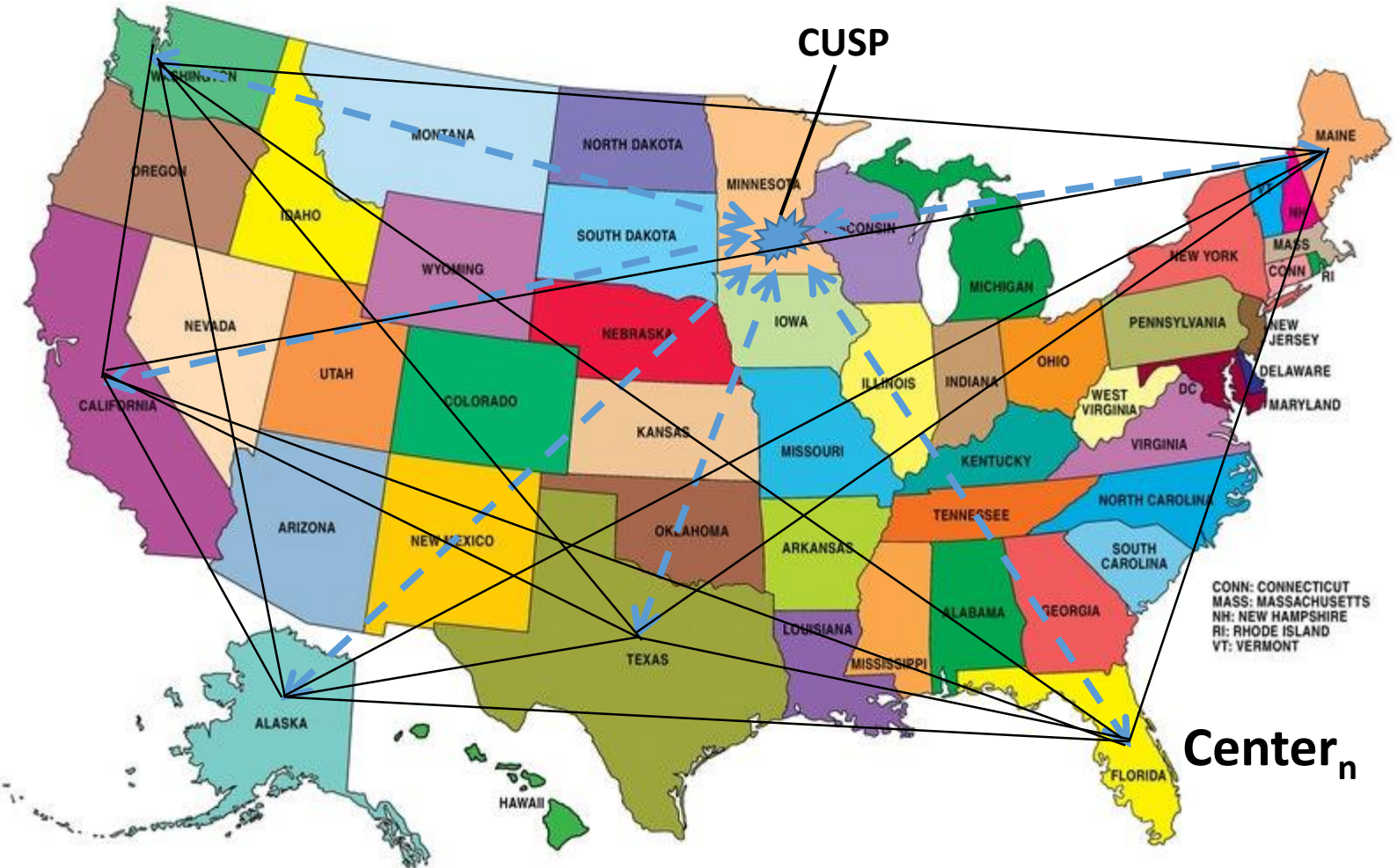
High School to Industry in just 2-1/2 Years (After AS Degree from Community Colleges)



The Makeup of these courses -

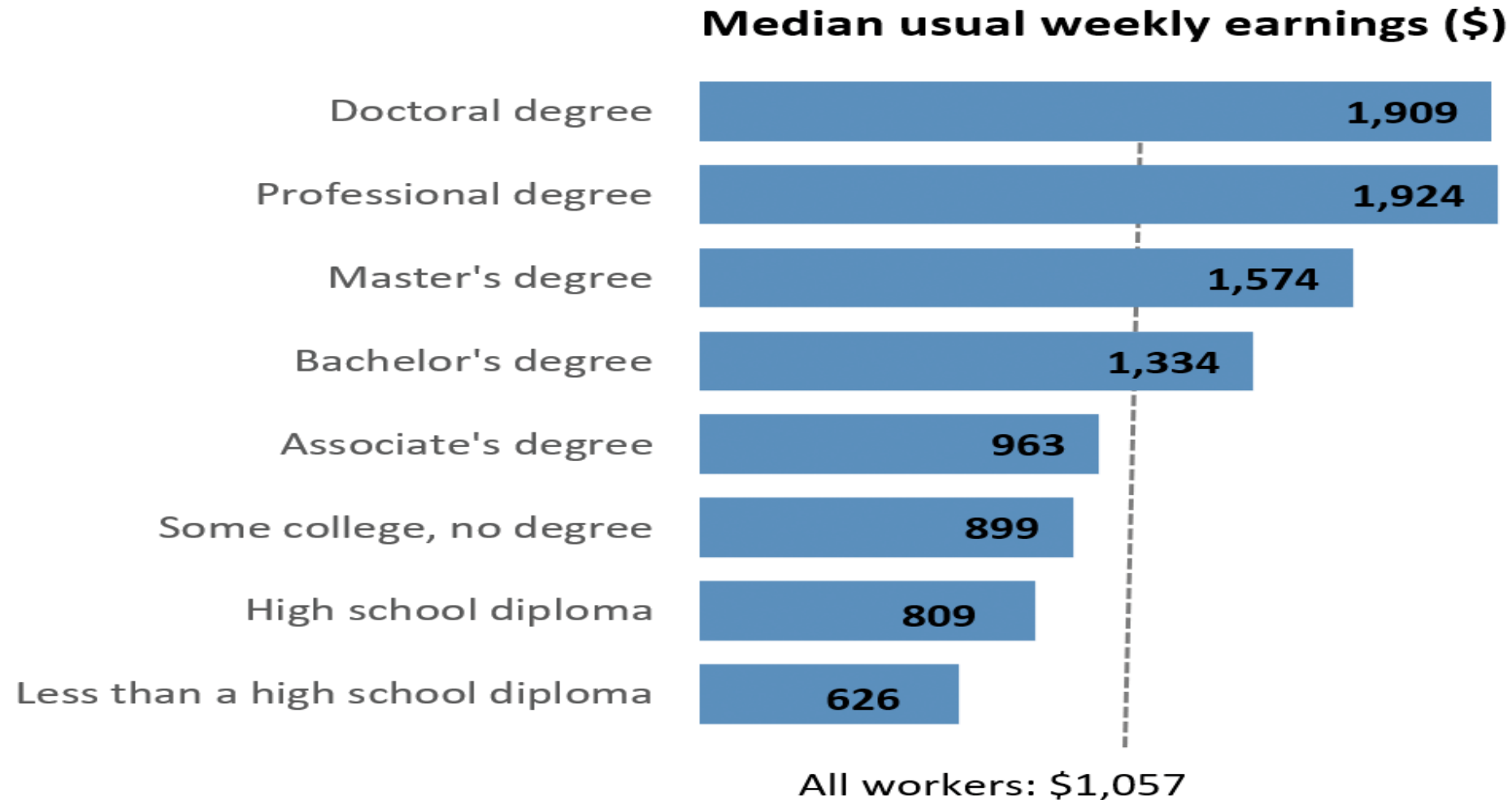
- Each Course will be 13 weeks long:
 - Lectures: 10 weeks + Labs: 3 weeks.
- Online
- Taught by web-based instructors from industry/academia
- Rigorous with assignments and exams
- Will include online hardware laboratories developed through ONR funding

A Highly Decentralized Certification Effort through Centers in Electric Power Engineering

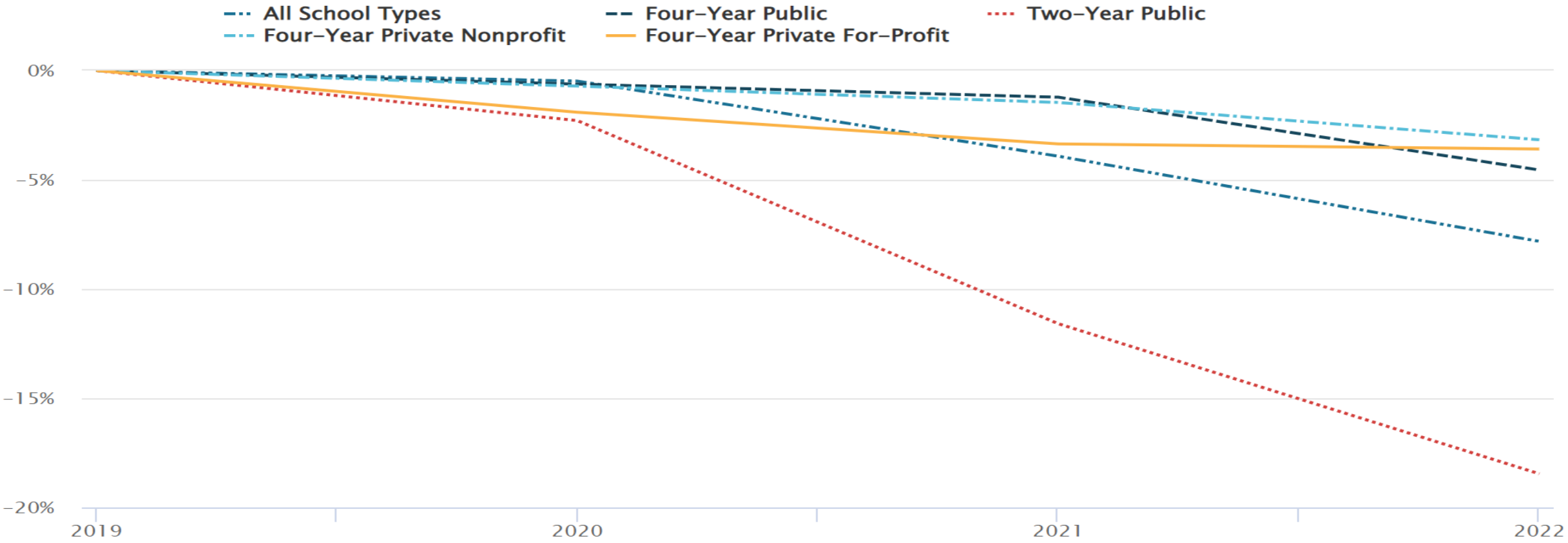


Why would students like it?

Earnings and unemployment rates by educational attainment, 2021



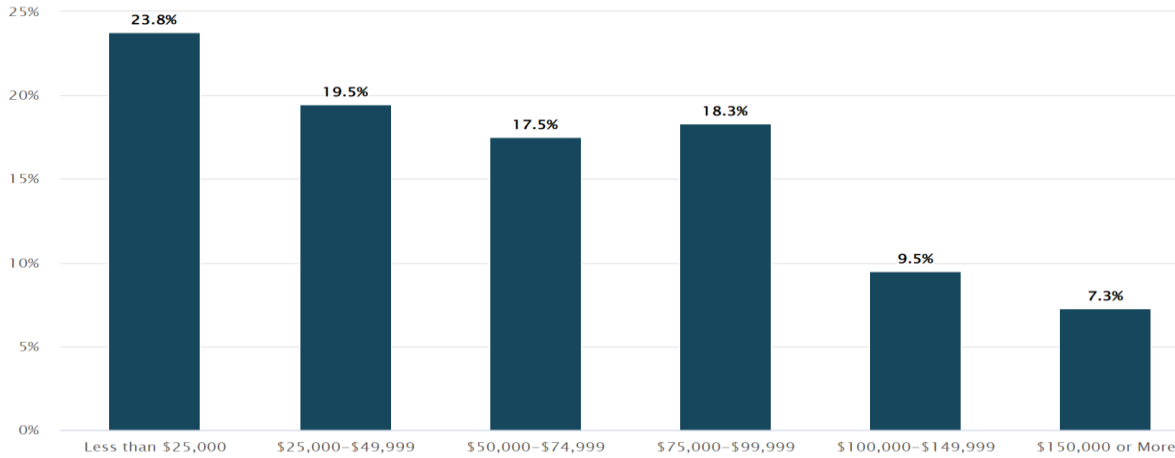
Why would Community Colleges like it?



Source: "U.S. College Enrollment Decline," Best Colleges

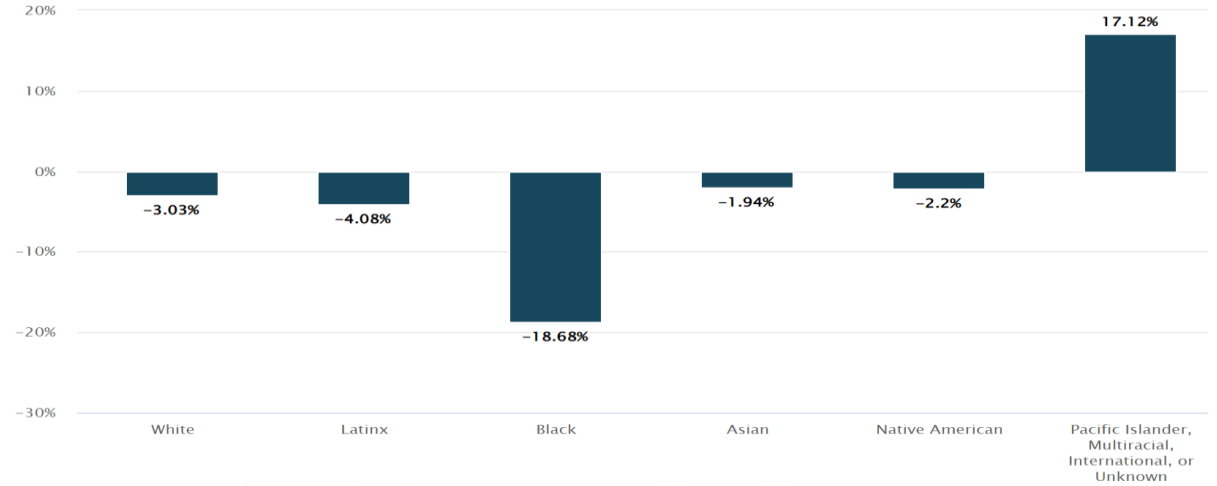
Why through Community Colleges?

Percent of Households That Canceled All Plans to Take Classes, August 2021



Source: NCES

2020-2022 First-Year Enrollment Decline by Race/Ethnicity

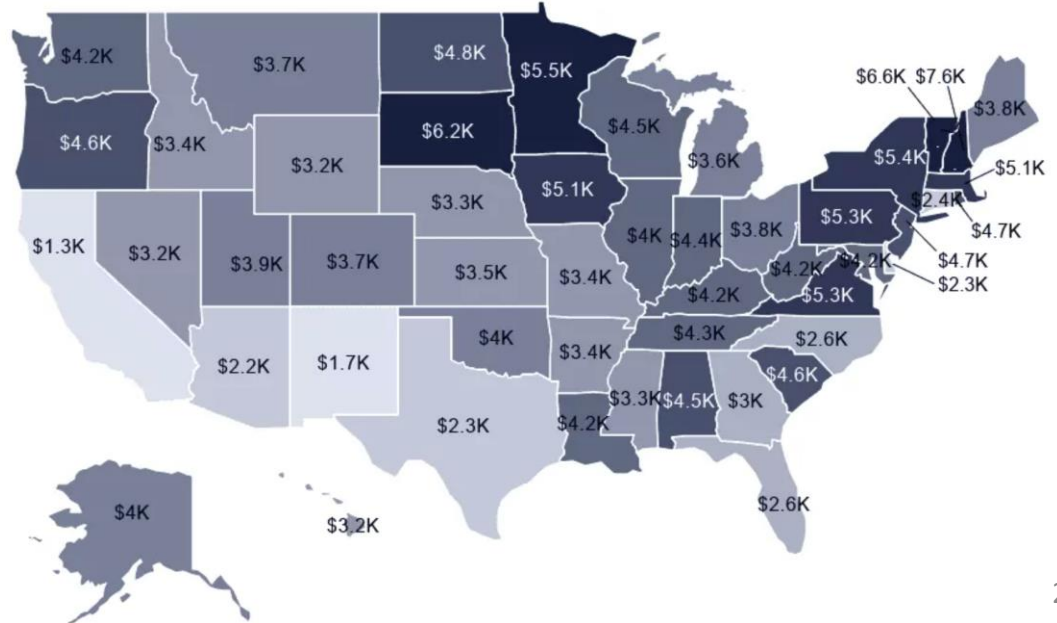


Historical Cost of College Tuition & Fees in 2021 Dollars



Source: "Average Cost of College by Year," Education Data Initiative

Average In-State Community College Tuition



Rural universities, already few and far between, are cutting majors

With budgets and enrollment crashing, some schools cut humanities in favor of 'workforce needs'

By [Jon Marcus](#)

Updated December 16, 2022 at 11:14 a.m. EST | Published December 16, 2022 at 8:00 a.m. EST

Several states are merging universities, many of which serve rural students. Pennsylvania has combined three universities in western and three in northeastern Pennsylvania, [consolidating programs and majors](#) into a mix of remote and in-person classes.

Higher education funding per student declined by more than 30 percent in Alabama, Louisiana, Mississippi, Oklahoma and Pennsylvania. In Kansas, it went down by nearly 23 percent.

“Think about whether people in urban and suburban areas would put up with” cuts like those...

In deciding what to cut and what to keep, officials at the universities said they're responding to public demand. A disproportionate number of humanities and science programs are being dropped.

With rural households earning what the U.S. Department of Agriculture calculates is [20 to 25 percent less](#) than urban ones, “it's a struggle for many of our students to afford” tuition, Thomas said. “They don't have the luxury of coming here to do something that's not going to pay off for them or their families.”

[Rural universities, already few and far between, are cutting majors - The Washington Post](#)

Why would Universities and 4-year Colleges like it?

[Rural universities, already few and far between, are cutting majors - The Washington Post.](#)

Why would University/College Professors like it?

- Funding
 - Your Center could easily have 10-15 industry members at 10-15 k\$/year

Why would Industries like it?

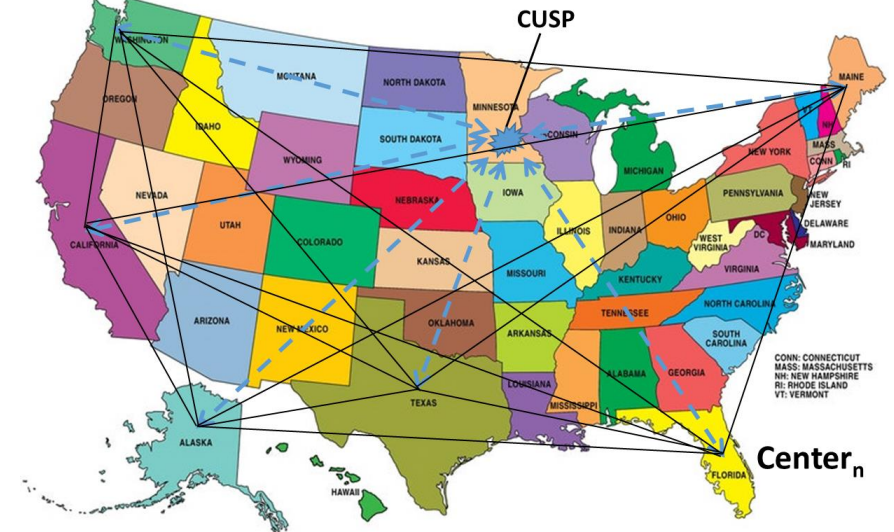
- They need employees
 - Retirements
 - Cash in on hundreds of billions of dollars in public investments through various congressional Bills and Acts
 - Opportunity to retrain their employees

All Types of Industries/Utilities:

- Electric Utilities
- Renewable Energy Developers
- EVs and EV Charging
- Transportation
- Defense
- Manufacturing of all types: Chip Manufacturing; Agricultural Equipment; HVAC; Etc.

Role of CUSP

- Develop the Certificate-related Courses and Labs, including the pipeline course
- Promote the Certificate Effort to various universities to form Centers and act as lead universities
- Identify industry instructors nationwide to teach these courses





CUSP

Home

Courses ▾

General Info

Join CUSP

Events

Contact

Home

Welcome to CUSP

The vision behind CUSP™ is to provide all the resources an instructor needs in teaching his/her own courses in the field of Electric Energy Systems with an emphasis on sustainability. This effort has been funded from various organizations including NSF, ONR (Office of Naval Research), NASA and EPRI and is totally free-of-cost under the Terms of Use conditions.

CUSP Welcome Video



NSF Workshop 2022

NSF Workshop ECE Department

Crisis in Power Engineering Education:
A National Security Concern
Minneapolis, MN October 21-22, 2022

To view the Workshop (click the image below):



Low Cost Laboratory

New low-cost basic and advanced electric drives laboratory.

'Face it head on': Connecticut makes climate change studies compulsory

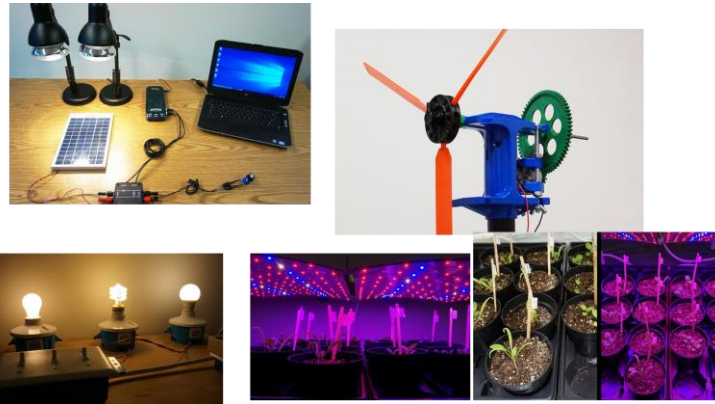


['Face it head on': Connecticut makes climate change studies compulsory | US education | The Guardian](#)

A Pipeline Course EE1701/1703



- **Online only**
- **111 students**
 - 85% from other colleges
 - 60% female



Being taught in five metro schools

<http://z.umn.edu/ee1701>

Dual-Credits, Concurrent-Enrollment Program



Post-Secondary Enrollment Option (PSEO)



Senior Citizen Education Program

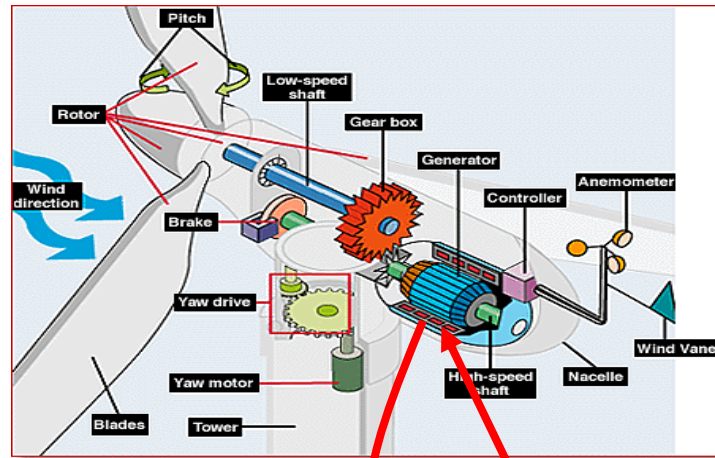


College while in high school: How dual credit is aiming for equity



The option of taking college courses while in high school is booming in the U.S. What will it take to transform dual credit learning into a true tool to advance equity?

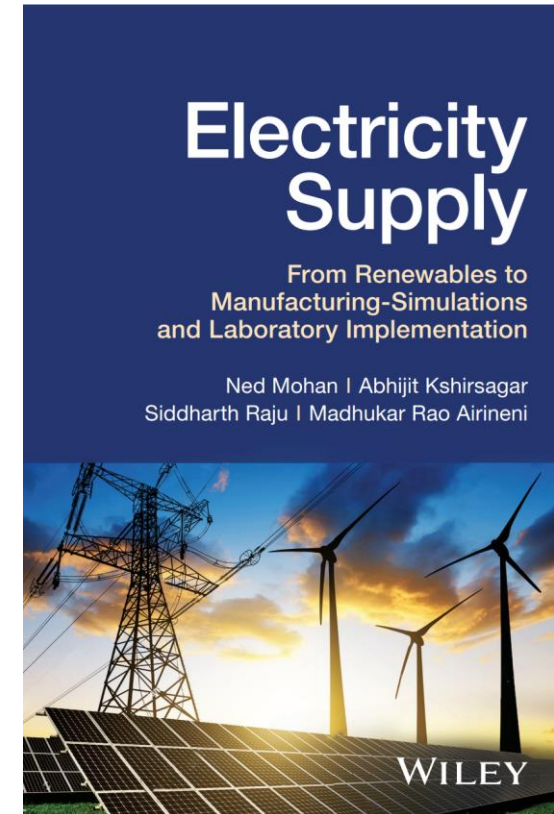
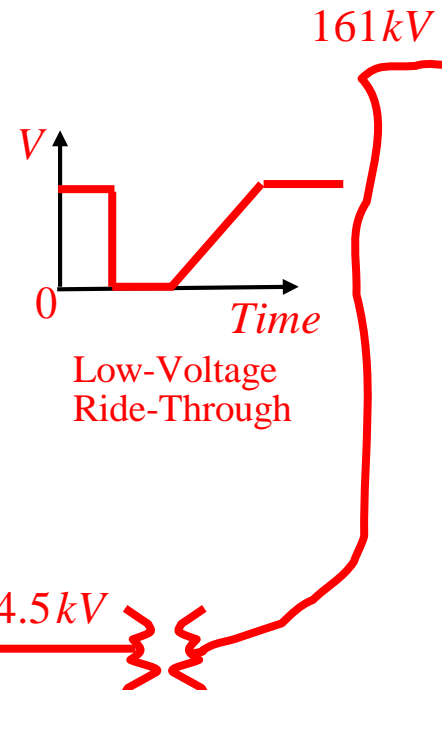
A System-Level Course: EE2701/2703 (under development)



0 – 690V
10 – 60 Hz

Generator

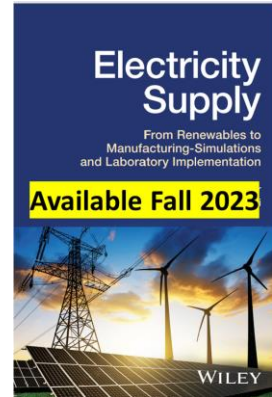
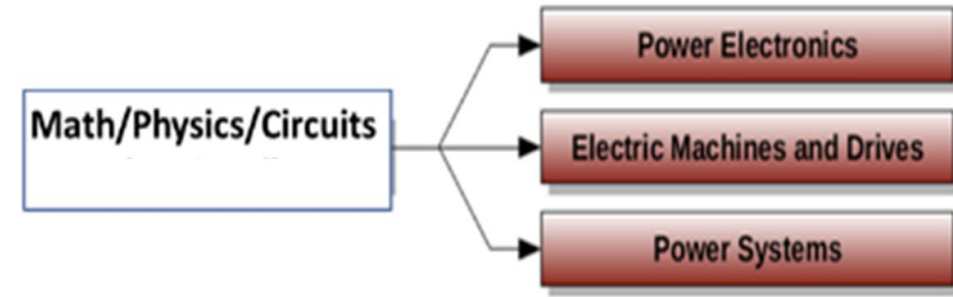
Power Electronics Converters



Math-Physics-Circuits: EPE300

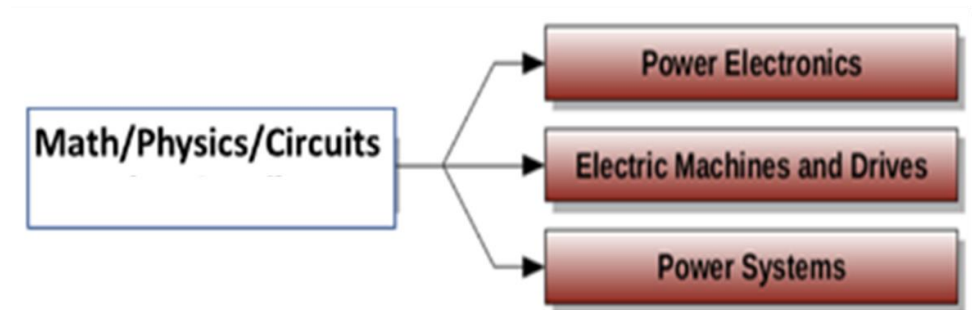
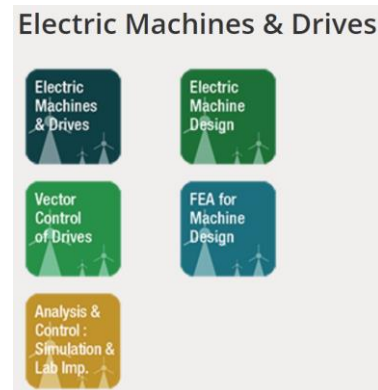
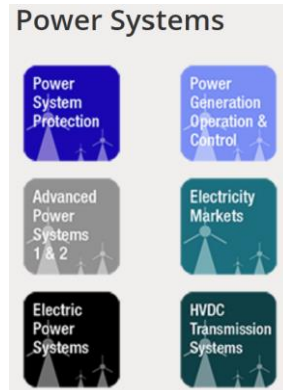
- Math:
- Basic Algebra (prerequisite)
- Basic Geometry (prerequisite)
- Basic Calculus (prerequisite)
- Complex number manipulation – coordinate transformation
- Concept of differentiation and integration
- Physics:
- Basic Physics (prerequisite)
- Voltage, Current, Power, Energy
- Resistance, Inductance, Capacitance
- Newton's Laws
- Mass, Inertia, Force, Torque, Speed, Acceleration
- Electric and Magnetic Fields
- Magnetic Flux
- Ampere's Law

- Faraday' Law
- Newton's Laws
- Mass, Inertia, Force, Torque, Acceleration
- Laws of Thermodynamics
- Circuits:
- DC Circuits: Ohm's Law, KCL, KVL, Thevenin equivalent, Power, Energy
- AC Circuits: R, L, C, Network Equations, Diff-Int Equation but not the solution (simulation)
- In sinusoidal steady state:
 - RMS, Phasors
 - single-phase
 - three-phase
- Superposition
- Harmonic Analysis
- Filters in a general sense (not their design)
- No FFT and no Laplace Transform



Lab under development

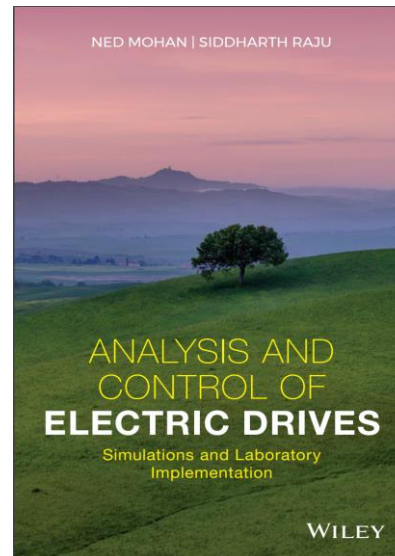
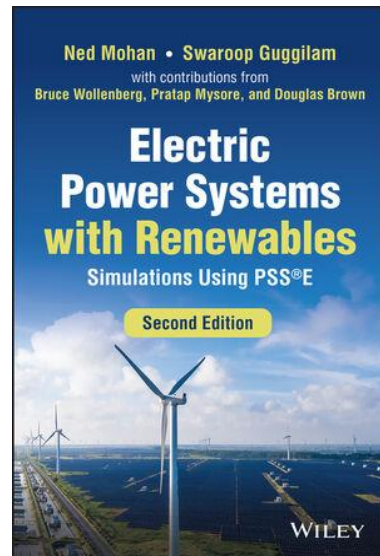
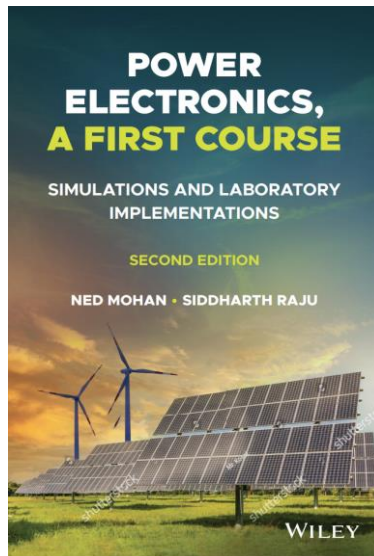
Power Electronics – EPE301, Power Systems – EPE302, Electric Machines/Drives – EPE303



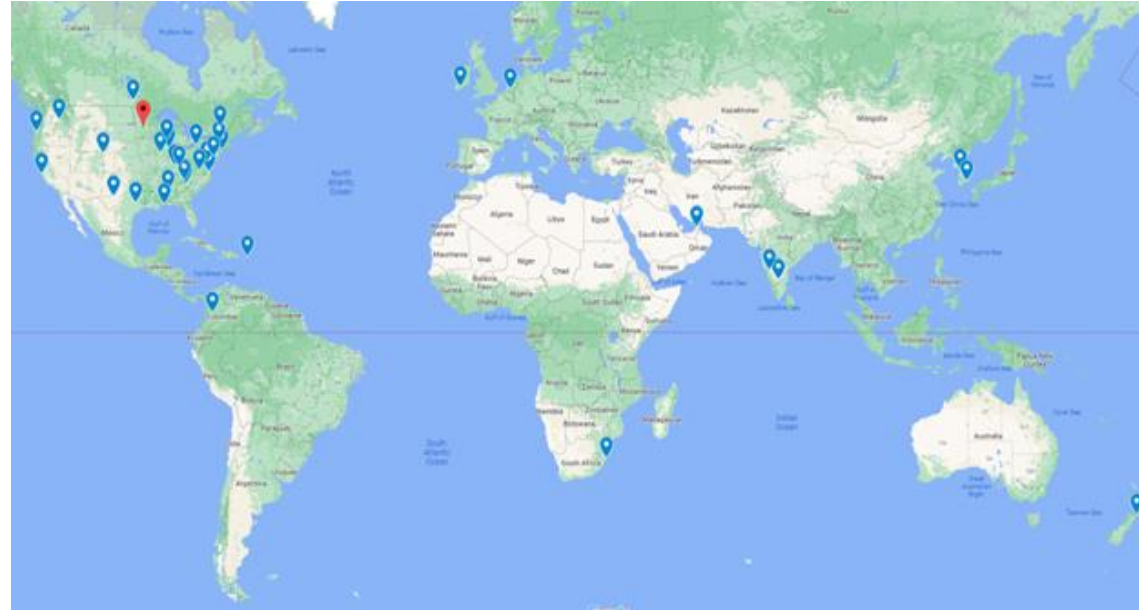
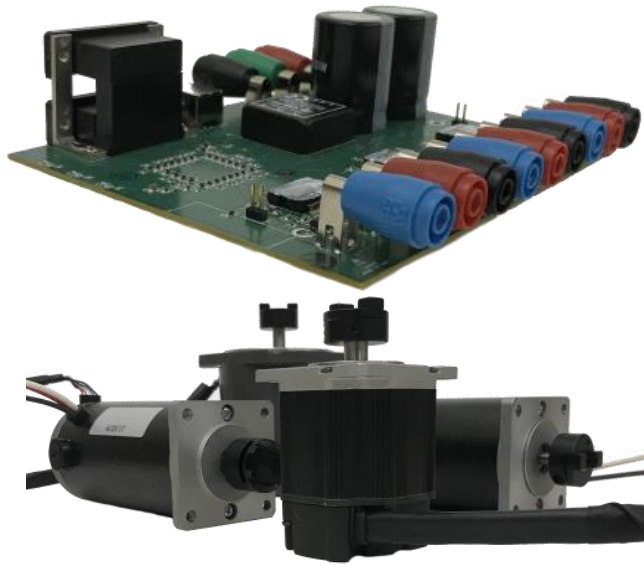
Course Slides Course Videos

Lecture Slides >

Lecture Modules >



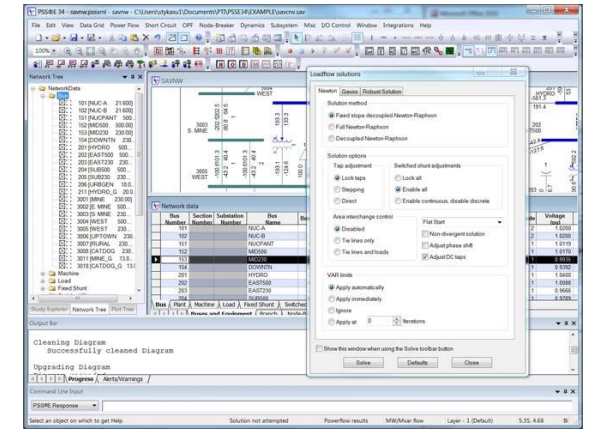
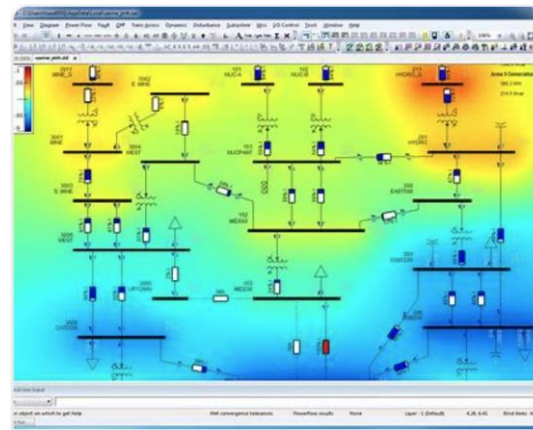
Remotely Accessible Hardware Laboratories



**Old NSF – CCLI Labs
Acquired by 109 US
Universities**

**New ONR-funded Labs
Already Acquired by 55
Universities**

Using the software that makes students industry-ready (PSS®E)

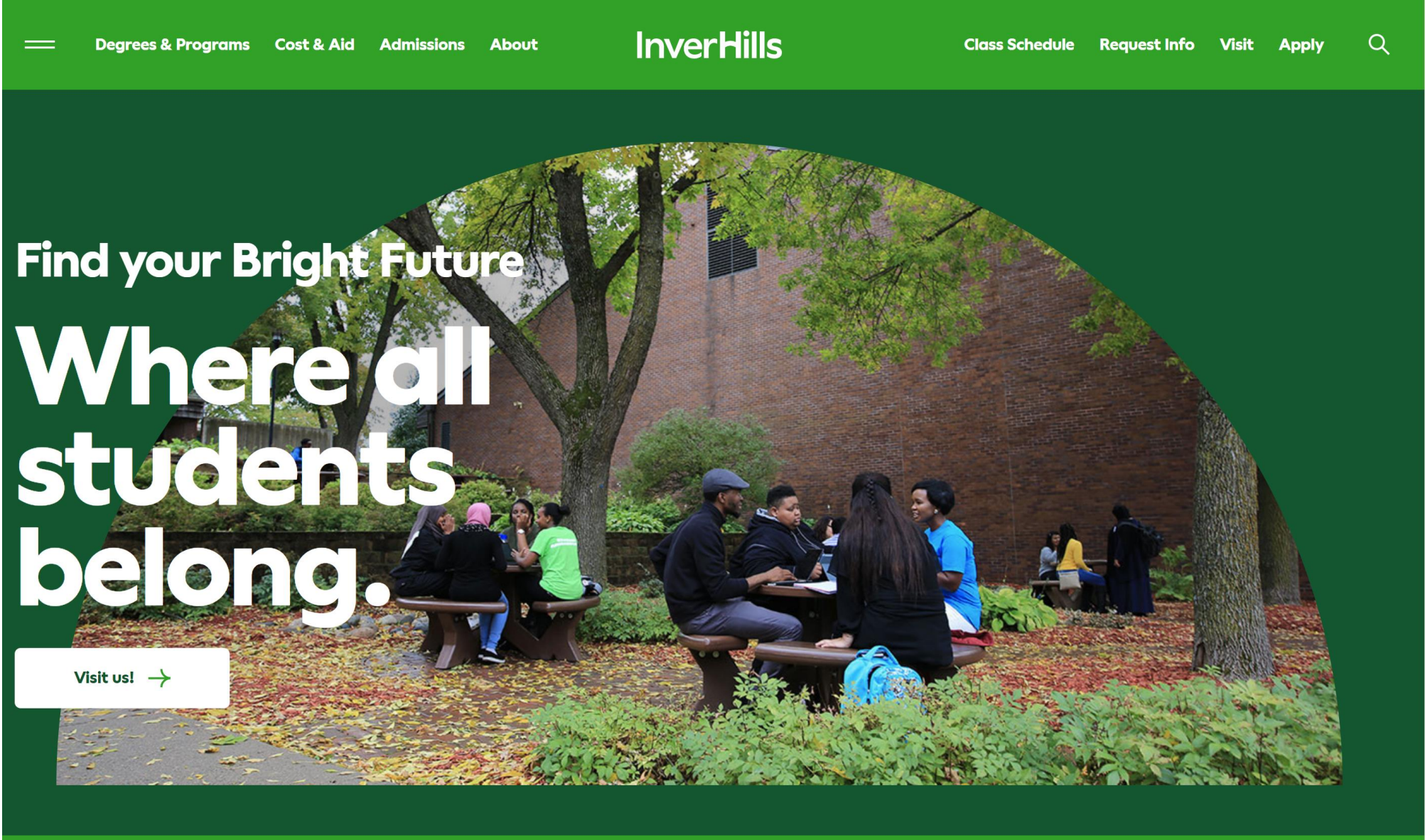


Revival of rural and urban communities alike

This approach proposed will democratize technical education:

- Bringing it to rural communities who otherwise would not have access to it
- To historically and systemically marginalized urban communities who otherwise do not see a pathway out of poverty and are priced out of traditional technical education options.
- To Tribal communities, and
- Disabled Americans

Can't Beat Success!

The image shows a website banner for InverHills. At the top, there is a green navigation bar with a hamburger menu icon on the left, followed by the links "Degrees & Programs", "Cost & Aid", "Admissions", and "About". The "InverHills" logo is centered in the navigation bar. To the right of the logo are the links "Class Schedule", "Request Info", "Visit", and "Apply", followed by a search icon. Below the navigation bar is a large green banner with a semi-circular cutout showing a photograph of students sitting at tables outdoors in a courtyard. The text "Find your Bright Future" is in a smaller white font, and "Where all students belong." is in a large, bold white font. A white button with the text "Visit us!" and a green arrow icon is positioned in the bottom left corner of the banner area.

Degrees & Programs Cost & Aid Admissions About

InverHills

Class Schedule Request Info Visit Apply

Find your Bright Future

Where all students belong.

Visit us! →



Crisis in Power Engineering Education: A National Security Concern



Minneapolis, MN October 21-22, 2022

- NSF
- ONR
- NAE
- ECEDHA
- ARPA-E
- Saint Paul Public Schools
- Minnesota State Colleges, and Universities
- Howard University

Over 110 Registrants-
Presentations uploaded:
<https://cusp.umn.edu>

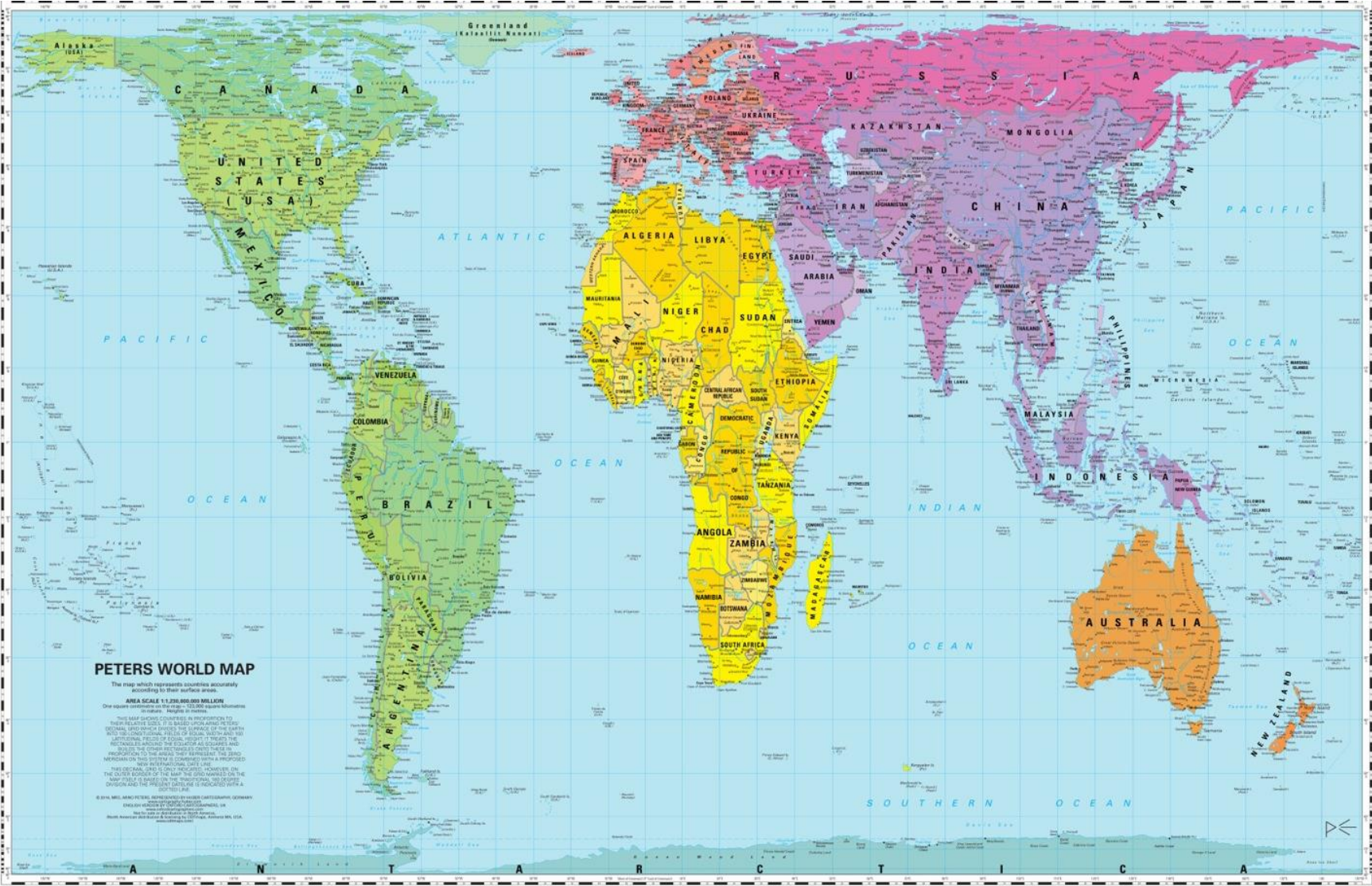
13 Posters from various
Industries – Buy-in

Industry Buy-in:

- Electric Utilities – Great River Energy; ACES Delta; Form Energy
- Electric Vehicles - Future of EVs; Tesla
- Industrial Manufacturing – Cummins Power Generation, John Deere, Siemens USA
- Microchip-related manufacturing – Intel
- Defense – Lockheed Martin



International Opportunity for Collaboration



Thank you!