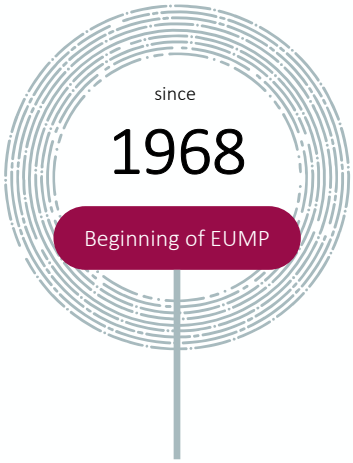
2022 Annual EUMP review AGENDA

Time	Topic	Who
8:30am – 8:45am	1. Welcome address by Dean Reddi, College of Eng.	Dean Lakshmi Reddi
8:45am -9:00am	2. Welcome and introductions	Dr. Ranade
9:00am –9:30am	3. Annual progress report (including classes and all other activities)	Dr. Lavrova
9:30am -10:30am	4. Leveraging Energy Storage Resources To Improve Combined Cycle Power Plant Operational Efficiency	Dr. Wang
10:30am-10:45am	5. Questions and Answers	All
10:45am - 11:00am	Break	
	Student presentations	
11:00am – 11:30am	a. Distributed DC Optimal Power Flow for Physically Distributed Nodes	Randy Woodall
11:30am – 12:00pm	b. Self-Healing Adaptive Alpha-Zeta Microgrid	Elijah Silva
12:00pm -12:30pm	Lunch	
12:30pm -1:00pm	c. Advancing Clean Energy and Electric Vehicle Infrastructure for the City of Las Cruces	Orland Whitney
1:00pm - 1:30pm	d. Hosting Capacity Analysis: software tools and framework	Agaba Ame-Oko
1:30 pm – 2:00pm	e. Simulation of Grid forming inverters and travelling wave behavior in microgrids	Frank Miyagishima
2:00 pm – 2:30pm	f. Exploring the use of Shapelets in Traveling Wave based Fault Detection in Distribution Systems	Shubha Pati
2:30pm -3:30pm	g. Lab projects	Sijo Augustine
3:30pm - 4:00 pm	Wrap-up, next steps, action items, discussion	O. Lavrova
4:30pm - adjourn	Optional: mini visit to Aggie Power 3MW PV array	

1



2

Established by industry to graduate MSEE Power Engineers for industry

1968

William Kersting Endowed Chair in Power Systems Engineering established by the **Arizona Public Service Company. Prof. Ranade appointed.**

2006

Professor Satish Ranade

Prof. Lavrova awarded prestigious WH Kersting Chair in Power Systems Engineering Position

2020

GOAL:

The Electric Utility Management Program (EUMP) leading to the degree of Master of Science in Electrical Engineering is designed to prepare the student for a future management position in the electric utility industry.
Funding for the Program is provided by the membership fees of participating companies.

CHARTER:

- To provide a program of study at the graduate level in the areas of electric power generation, transmission, distribution, utilization and in the planning, operation, regulation and management of these facilities.
- To provide a program where faculty and graduate students can perform research on projects suggested by the faculty and/or requested by the industry.
- To provide a program where short courses can be presented on campus and off campus to assist in the continuing education of industry engineers and managers.
- To provide the electric utility industry with the highest caliber of new engineering and management talent.
- To provide the electric utility industry with a method to access the technical resources available at NMSU through membership in the program.

EUMP at NMSU

2022

#BeBold
#ShapeTheFuture

BE BOLD. Shape the Future.

Prof. Olga Lavrova

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ELECTRIC UTILITY MANAGEMENT PROGRAM

2022 Annual Report

Klipsch School of
Electrical and Computer
Engineering
New Mexico State University
Las Cruces, NM 88005
http://www.ece.nmsu.edu/~eump

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Prof. Olga Lavrova

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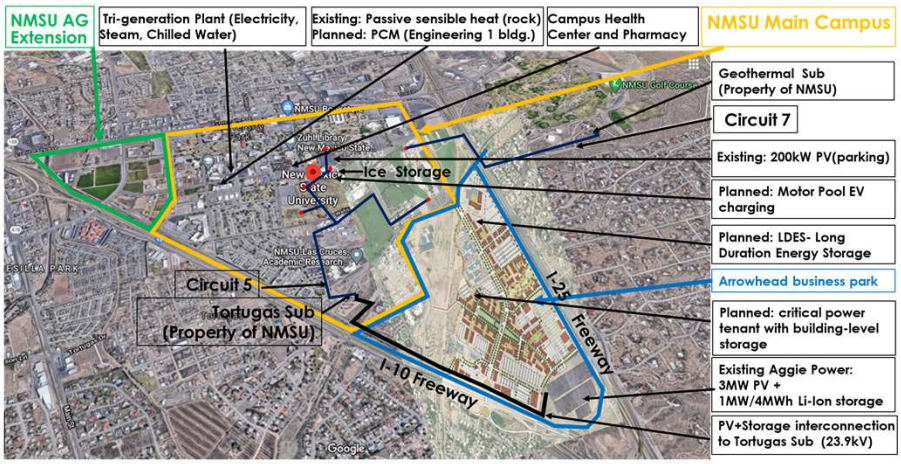
Positioning NMSU as Large-scale Clean Energy Demonstration Site



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Electric Utility Management Program

Members provide annual funding

$75,000-$125000

Funding used for
- Student Stipends/Tuition
- Faculty Support
- Travel
- Equipment/Software

Leverages to research
- Expenditures $300,000
- MS/PhD RA and post doc

Core Members:
NM Electric Coops
PNM
EPE
APS

TABLE I
INITIAL STUDENT AND FELLOW PLACEMENT.

Student Placement	All Students		Fellows	
Member Companies	173	51%	150	67%
Non-Member Utility Companies	13	4%	11	5%
Non-Member Companies	155	45%	64	28%
Totals	341	100%	225	100%

TABLE II. GRADUATE PLACEMENT BY SPONSORING COMPANY

Company	
Electric Utilities	161
Electric Co-Ops	13
Power Electronics and Components manufacturing companies	31
Total	**197**

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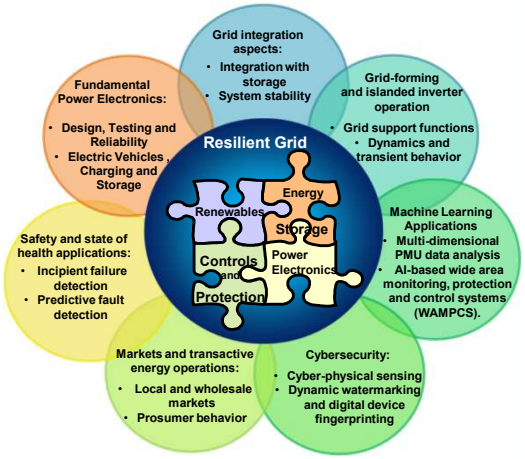
Over-arching research areas:



Devices and Integrated Systems

Sensing and Measurement

System Operations and Control

Design and Planning Tools

Security and Resilience

Teaching and Research Infrastructure:

- El Paso Electric Power Laboratory laboratory supports bot instruction and research for the Power and Control group in the Klipsch School of Electrical and Computer Engineering at NMSU.
- In addition to standard instruments, the laboratory has six LabVolt test benches which can be configured using motor-generator sets as generating sources or loads.
- Several stations feed power from a rooftop PV array.
- The substations can be remotely controlled using a wireless network

- Developed data acquisition system for solar microinverters and energy storage system
- Currently can monitoring electrical performance and power quality data from :
  - most NMSU buildings panels (electrical),
  - microinverter power production from PV system on Thomas &Brown roof
  - From battery storage system on Thomas &Brown roof

New changes

- This is probably the last time we meet in this building.
- New building is coming soon!

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New changes

- Thanks to EPE and SEL for the new donation!
- New SEL rack is in the lab
- Will be used for teaching (hands-on lab for the protection and relaying class) and research

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The Curriculum

	Departmental Core	Energy Systems	Electives
Undergraduates typically take 3 energy systems courses in addition to the required Introductory class. They can take MS classes under a dual credit program	EE 391 Introduction to Power Systems I	EE431/542 Power Systems II	Public Utility Regulation I
	EE391 is being replaced by EE230	EE 493/543 Power Systems III	ET 381 Intro. Renewable Energy
MS and PhD students are required to take 3 core classes. MS students often declare a minor or certificate in Economics	EE543 Power Systems III	EE531 Power Network Modeling and Simulation	ECON571Regulatory Policy and Industry Analysis :Electricity I
	EE571 Random Signal Analysis	EE494/544 Distribution Systems	ECON573Regulatory Policy and Industry Analysis :Electricity II
	EE551 Control Systems I	EE534 Protective Relaying	ECON574Seminar: Regulatory Policy and Industry
	EE563 Computer Performance Analysis	EE532 Dynamics and Transients	IE 531 Fund. of OR
	EE529Lasers and Applications	EE537 Power Electronics	EE563 Topics in Engineering Administration
	EE524Digital VLSI	EE533 Power System Operation	
Doctoral students take 18 credits beyond the MSEE	EE515Electromagnetic Theory	EE 600 Advanced Dynamics and Control	MATH586 Nonlinear Dynamics I
	EE545 Digital Signal Processing		EE552 Control Systems Synthesis

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Current Classes offered:

Class	Spring 2021	Fall 2021	Spring 2022	Fall 2022	Spring 2023	Fall 2023
EE 317 Electronics		Gangineni	Gangineni			
EE 230 - DC and AC circuits	Herrell	Basu	Basu	ET	ET	
EE 333 - Power 1	Wang	Augustine	Augustine	Augustine	Wang	TBD
EE 431/ 542 - Power 2		Lavrova	Wang	Wang	Lavrova	
EE 493/ 543 - Power 3	Lavrova			Ranade		TBD
EE 440/ 540 Photovoltaics			Lavrova			
EE 544 Distribution systems	Ranade				Ranade	
EE 532 Dynamics of Power Systems			Ranade			
EE 533 Power Systems Operation				Wang		
EE 534 Power System Relaying		Ranade				Ranade?
EE 432/ 537 Power Electronics	Nademi			Lavrova		
(new number) Electricity Markets		Wang			Wang	
EE 546 Smart Grid (CS-514/494)				Lavrova		
Numerical Modeling Methods for Smart Grid Applica					Lavrova	
(new number) Optimization Techniques for Power Sy						Wang

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Power Systems Operation: Syllabus

Lecture 1 (08/19): Overview of power systems operation and economics
Lecture 2 (08/24): Generation model
Lecture 3(08/26): Economic dispatch
Lecture 4(08/31): Linear Programming
Lecture 5(09/02): AC and DC flow
Lecture 6(09/09): PTDF Calculation
Lecture 7(09/14): Power System security, Contingency Analysis
Lecture 8(09/16): SCED. RTO Monitoring
Lecture 9(09/30): Mixed integer programing
Lecture 10(10/05): Unit commitment
Lecture 11(10/07): Unit commitment
Lecture 12(10/12): Ancillary service
Lecture 13 (10/14): Generation control
Lecture 14 (10/19): Automatic generation control
Lecture 15 (10/21): RTO Operation
Lecture 16 (11/02): Short-term Load forecasting
Lecture 17 (11/04): Renewable integration
Lecture 18 (11/09): Transmission planning and Resource adequacy
Lecture 22 (11/30): Final project presentation
Lecture 23 (12/02): Final project presentation
Lecture 24 (12/07): Final project presentation
Lecture 25 (12/09): Final project report

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Electricity Markets: Syllabus

Lecture 1: Overview of power systems operation and economics
Lecture 2: Basics of Microeconomics
Lecture 3: Market power and basics of game theory
Lecture 4: Market equilibrium models (Oligopolistic, Cournot, Bertrand)
Lecture 5: DEC game and second best
Lecture 6: Introduction to linear programming
Lecture 7: Duality I
Lecture 8: Duality II
Lecture 9: Economic dispatch
Lecture 10: Dual of DCOPF
Lecture 11: Mixed integer programing
Lecture 12: Unit commitment I
Lecture 13: Unit commitment II
Lecture 14: Electricity Market Pricing
Lecture 15: Electricity market settlement
Lecture 16: Financial transmission right
Lecture 17: Nonconvex electricity market design and uplift payment
Lecture 18: Ancillary service market
Lecture 19: RTO Operation
Lecture 20: Nonconvex electricity market and uplift payment
Lecture 21: Transmission planning and Resource adequacy
Lecture 22: Challenges of today's electricity market design
Lecture 23: Final project presentation
Lecture 24: Final project presentation
Lecture 25: Final project report

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Syllabus: Distribution Systems

1. Introduction (1 lecture)
   Structure and evolution ANSI Service defined Reliability and cost Challenges
2. (Kersting) Modeling Demand(1 lectures)
   Definitions, Diversity, Internal standard development
3. (Kersting) Back-of-the envelope design (2 lectures)
   Uniform lateral analysis, Geometric design, Capacitor application (2/3-2/3 rule)
4. (Kersting, EMTP Theory book, Notes) (4 lectures)
   Inductive impedance and capacitance calculation, Grounding and stray voltage/current
5. Distribution Power Flow (Kersting, Notes, Open DSS resources) (3 lectures)
   Ladder, Impedance matrix, Open DSS
6. Regulation of voltages (Kersting, Cooper catalog) (2 lectures)
   Capacitor application Voltage regulator
7. Fault Study(1 lecture)
8. Motors and Motor Starting(Voltage dip study) (2 lectures)
9. Distributed Energy resources
   Technology, Issues, Hosting Capacity
10. (Short)Transformer Application(2 lectures)
11. (Cooper Distribution Handbook) Protection(3 lectures)
    Fuses, Reclosers and Sectionalizers, Coordination
12. (Short, Gonen) Reliability (3 lectures)
    Empirical (SAIFI/SAIDI) Reporting, Improvement, Analytical – Block diagrams, Monte Carlo

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Syllabus: Power Electronics

DATE	TOPIC	READING	HOMEWORK
Jan./25	Introduction and Review of power electronics systems	Chapter 1/ Notes	
Jan./27	Solid-State Power Devices: Diode & Transistor	Chapter 2/Notes	
Feb/01	Solid-State Power Devices: Insulated Gate Bipolar Transistors (IGBTs)	Chapter 2/Notes	
Feb/03	Solid-State Power Devices: MOSFETs	Notes	
Feb/08	Solid-State Power Devices: Thyristors	Notes	Assignment #1
Feb/10	Pulse-Width-Modulation (PWM) Methods	Notes	
Feb/17	Pulse-Width-Modulation (PWM) Methods	Notes	Assignment #2
Feb/22	DC-DC Power Converters	Chapter 3/Notes	
Feb/24	DC-DC Power Converters	Chapter 3	
Mar/01	DC-DC Power Converters	Notes	Assignment #3
Mar/03	Design of Feedback Controllers in Switch-Mode Power Supplies	Chapter 4	
Mar/08	Regulated DC Power Supply	Notes	
Mar/10	Characterizing the Nonlinear Loads	Notes	Assignment #4
Mar/15	Diode-Bridge Rectification	Chapter 5	
Mar/17	Effects of Modulation indices: Fundamentals	Chapter 6	
Mar/22	Effects of Modulation indices: Simulation Analysis	Chapter 9	Assignment #5
Mar/24	Full-Bridge and Half-Bridge DC Power Supplies	Chapter 8	
Mar/29	Review of all topics	Notes	
Mar/31	**Mid-term Exam**		
Apr/05	Synthesis of DC and Sinusoidal AC Voltages		
Apr/07	Synthesis of Single-phase and Three-phase AC Systems		
Apr/12	Three-Phase Thyristor Converters	Chapter 12/	Assignment #6
Apr/14	Converter Ratings in Various Applications	Notes	
Apr/19	Utility-Related Applications of Power Electronics	Notes	
Apr/21	Power Electronics for Wind Power Generation	Notes	
Apr/26	Power Electronics for Solar PV Generation and Battery Energy Storage	Notes	Assignment #7
Apr/28	Power Quality Problems	Notes	
May/03	Emerging Power Converters: Multilevel Topologies	Notes	
May/05	Review of all topics	Notes	
May 10	Final Exam (may be replaced by a take home exam/project)		
May 13	Final Project deadline		

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Syllabus: Photovoltaic Devices and Systems

Week 1 January 22	• Overview of renewable energy sources (solar, wind, hydro, geothermal, tidal wave, etc) • Solar Spectrum
Week 2 January 27 January 29	• Determination of azimuth and altitude angle for different locations, time of day, time of year • Solar flux dependence on these angles
Week 3 February 3 February 5	• Basic Solar Cell operation in theory • Solar Cell Operation in practice (heating, bypass diodes, etc)
Week 4 February 10 February 12	• Power curve, maximum power point • Solar Cell operation – device level, p-n junction, pin solar cell
Week 5 February 17 February 19	• Carrier transport mechanisms, how they affect solar cell performance • First approximation calculation of generation current and Voc
Week 6 February 24 February 26	• Theoretical Efficiency limits • Performance and tradeoffs depending on solar cell geometry (area, thickness)
Week 7 March 2 March 4	• Various Solar Cell materials • Performance, cost and lifetime tradeoffs between different material systems
Week 8 March 9 March 11	• Optimization of metal contacts • Optimization of AR coating and minimization of reflection
Week 9 March 16 March 18	• Putting real solar cell module together (manufacturing point of view) • Mid-term exam
Week 11 March 30 April 1	• • Using SAM software
Week 11 April 6 April 8	• Putting a solar system together – other balance of system components (BOC) (MPPT, inverter, storage, other) • Sizing of a mid-size solar system (residential applications), selection of BOC components
Week 12 April 13 April 15	• Interconnection with utility, safety, operation and maintenance • Sizing of a large-scale solar system (commercial and small solar farm)
Week 13 April 20 April 22	• Utility-scale Solar Power generation • Concentrated CPV principles, trade-offs and cost
Week 14 April 27 April 29	• Designing for stand-alone and other remote applications • Storage

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New Class in Planning: Cybersecurity for Utilities Operations

Module 1: Cybersecurity Fundamentals

- There three As of security
- Meanings of security, privacy, access control, denial of service, etc.
- Some well-known attacks on cyberphysical systems.
- Symmetric key encryption
- Public Key infrastructure
- Message authentication codes

Module 2: Applications to utility sectors

- Baselining and Measuring Cybersecurity Operations
- Identification and forensics of cyber-incidents in electric utility infrastructure, intrusion and breach detection
- Cyber Strategies for Industrial Control Systems
- Residential AMI privacy and cybersecurity concerns
- Cybersecurity aspects as applicable to renewable energy generation

Module 3: Hands-on practicum

- Addressing federal and local standards and regulations: CIP, FIPS 199, CMMC 17, local PRC requirements.
- Information sharing requirements
- Compliance with energy backup programs

Incident response

- Hands-on activities, developed jointly between SNL and NMSU. Examples of activities are: Mini-Mega, Tracer Fire or similar

NM STATE **BE BOLD.** Shape the Future. Prof. Olga Lavrova

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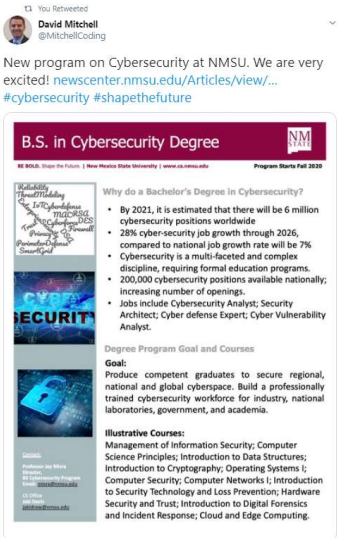
Lots of opportunities beyond classes!



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Notable news, initiatives and program development:

- Dr. Ranade named an IEEE Fellow !
- "The IEEE Fellow is one of the most prestigious honors of the IEEE, and is bestowed upon a very limited number of senior members who have contributed importantly to the advancement or application of engineering, science and technology bringing significant value to our society. The number of IEEE Fellows elevated in a year is no more than one-tenth of percent of the total IEEE voting membership," notes the organization's website.
- Dr. Ranade was recognized "for contributions to integration of renewable and distributed energy resources into power systems."

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Notable new initiatives and program development:

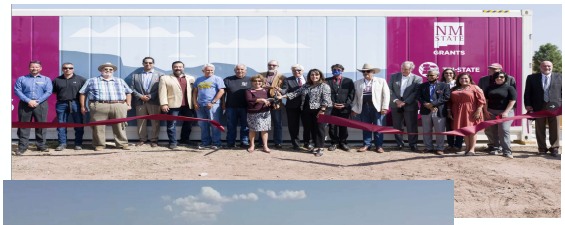
- Ribbon cutting: EPE on 3MW PV and 1MW/4MWh Storage "Aggie Power" project
- M.Sc. Graduate student Andres Acosta gave a keynote address
- NMSU EUMP will collaborate with EPE on research goals for PV+Storage operations.

New Mexico State University Chancellor Dan Arvizu and El Paso Electric President and CEO Kelly Tomblin, center, sign a solar panel Thursday, Sept. 23,

23

Notable new initiatives and program development:

- Ribbon cutting of the Indoor AG food growth project:



Indoor Agriculture Nanogrids Technical Standards Committee

- NMSU will develop DC power solution

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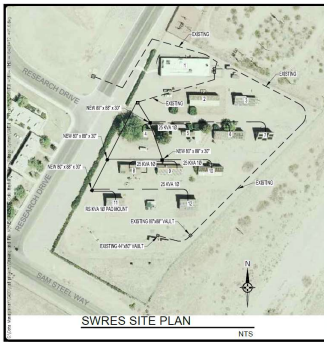
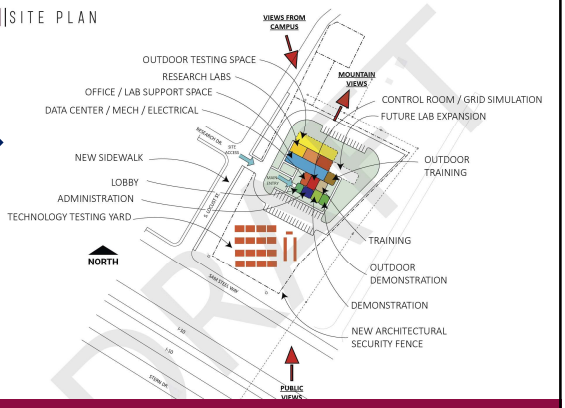
SWTDI becomes IDEAL

IDEAL: Integrated Digitally-networked Enterprise Accelerator Laboratory

New Building is in the works too !



SITE PLAN



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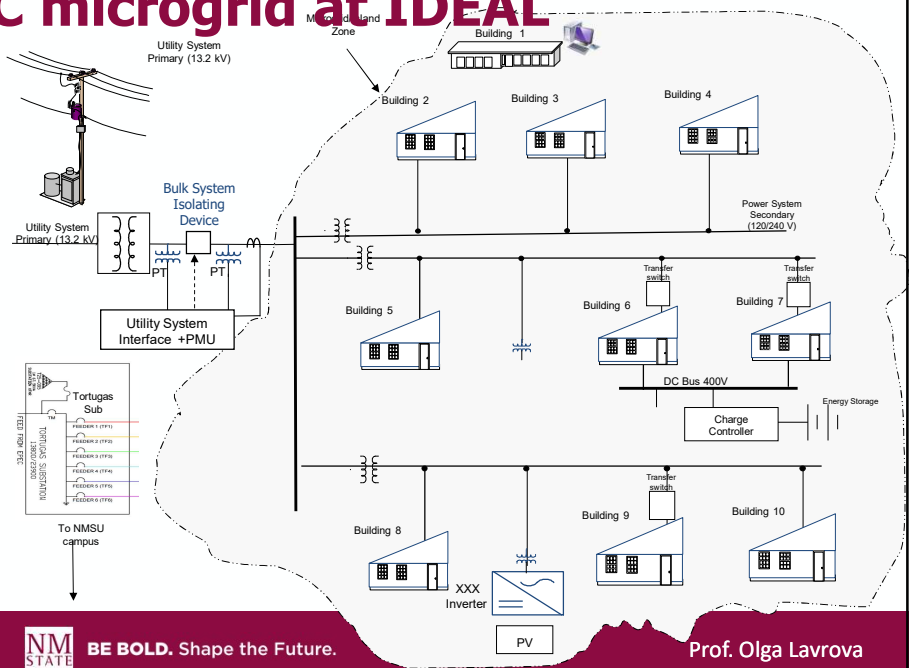
DC microgrid at IDEAL



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DC microgrid at IDEAL

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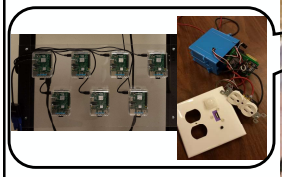
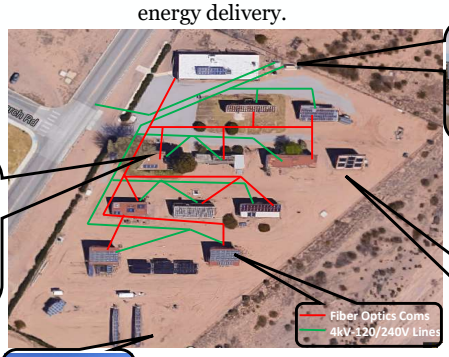
Site diagram

The micro-grid at IDEAL center is a three phase, 4kV feeder interconnecting buildings containing PV interfaced with smart inverters, Controllable Loads, Electric Storage and cybersecurity equipment. SWTDI provides the platform to evaluate centralized or distributed algorithms for energy delivery.

Resources and plug loads can be controlled using Smart Outlets. The outlets are capable of providing sensing and measurement information (Voltage, Current, Phase, etc.) and control connected resources.



Raspberry Pis are being programed as agents to execute the centralized or distributed algorithms for Energy Delivery. Programmable loads and load banks can be controlled to emulate various operating conditions and loading scenarios.



Additional Solar+Storage installation is underway. 3MW PV (single axis tracking) and 3MW/?? MWh storage is joint EPE / NMSU Research & Education Collaboration Agreement. Storage system will be controlled and dispatched for grid-support services.

IDEAL can be islanded from the utility by operating a set of three-phase reclosers (controlled by NMSU). System can operate as a microgrid. PMUs are co-located and monitored for emulitics and Machine Learning analysis

Both grid-forming and grid-following inverters manage power and energy balance.

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Notable new initiatives and program development:

- City of Lac Cruces Utilities became a new member of EUMP !
- Thanks to Lucio Garcia and Delilah Welch for support
- Also, thanks to Lisa Larocque for additional ideas
  - Presentation by Orland after lunch

City of Las Cruces

Notable new initiatives and program development:

USDA

- USDA Specialty Crop grant just awarded a grant for demonstration of Agriculture and Photovoltaics (Agrivoltaics) at NMSU's Fabian Garcia research station

Notable new initiatives and program development:

- Cindy Valdez won best student presentation award at EPSCOR student presentations

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Notable new initiatives and program development:

- Developed a strategic roadmap with Sandia National Labs in the area of Clean Energy!
- Contributing to the NM PRC working groups and technical committee meetings on PV interconnection standards update, Community Solar and Hosting Capacity studies
- EUMP specifically selected to work on the hosting capacity pilot project for NM
  - Preliminary presentation by Agaba

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Notable new initiatives and program development:

- Thanks to Jonathan Trejo and Alejandro Castro for organizing the meeting with Kelly Tomblin, EPE CEO, to continue establishing further collaborations with EUMP
- Thanks to Steve Cumming and Philo Shelton from Los Alamos County for reaching out about potential collaborations

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Current Team – all students:

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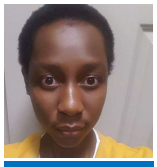
Just graduated students:



Ada Ramoko
Ph.D. E.E.

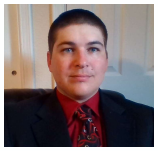
Thesis: A case study using protective relaying mechanisms for grid tied microgrids

Presently Freeport, was grad rotational program at Chevron-Phillips

Andres Acosta
M.S.E.E.

Thesis: Grid tied and Grid Forming Inverter Operation Analysis

Presently: at EPE, Distribution



Randy Woodall
M.S.E.E.

Thesis: Distributed DC Optimal Power Flow for Physically Distributed Nodes

Presently: at Sandia National Labs

George Nail
M.S.E.E.

Thesis: Simulation analysis of critical loads: Distribution planning for nonhomogeneous EV distributions
Presently: employed Burns & McDonnell in the T&D Global Partner, designing new substations and existing substation equipment.

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Last year's graduated students:

Ransome Egunjobi
Ph.D. .E.E.

Thesis: USING DISTRIBUTED ENERGY RESOURCES TO IMPROVE VOLTAGE STABILITY IN ANNUAL TRANSMISSION PLANNING ASSESSMENT

Presently: Senior Transmission Planning Engineer, Lower Colorado River Authority, Austin, Texas

Chris Carr
M.Sc.E.E.

Thesis: Simulation of Transient Traveling Waves in Electric Power Systems

Presently: at Timmons Group, - Power Engineering & System Planning, working on designing large scale solar/wind layout and interconnection planning)

Brynden Williams
B.Sc.E.E

Presently: employed at Arizona Public Service Electric

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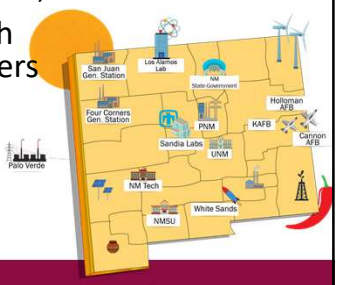
Future plans and opportunities

- Continue Collaborations with YOU, OUR PARTNERS, resulting in high caliber of student graduates and high level of technical publications and presentations;
- strengthen industry efforts to attract students through internships and coop programs;
- financial support that makes it possible for many of our students to commit to a graduate education;
- attract them to full time positions through competitive salaries and challenging careers
- define the new skill sets our students must acquire and create curricula that deliver these skills.



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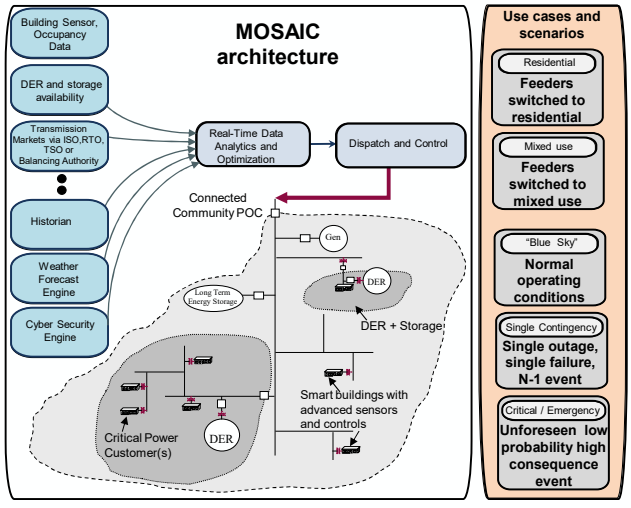
Other projects: MOSAIC architecture



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Discussion and Action Item(s):

We are excited about the program growing
Let's talk more collaborations !