Benefits of AI/ML Applications for BESS

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EXTENDING RANGE

Overview of Issues in BESSs

Battery Energy Storage Systems (BESS) face several challenges that impact their efficiency, lifespan, cost-effectiveness, and safety.

1. Performance & Efficiency Limitations
    - Energy dispatch in BESS is often based on static rules or predefined schedules, leading to suboptimal energy utilization.
    - Grid fluctuations and demand variations require real-time adjustments, which conventional systems struggle to handle.

2. Battery Degradation & Reduced Lifespan
    - Batteries degrade over time due to overcharging, deep discharging, and thermal stress.
    - Lack of predictive maintenance leads to premature battery failures and higher replacement costs.

3. High Operational Costs & Inefficient Grid Integration
    - Electricity prices fluctuate throughout the day, but without smart optimization, BESS cannot maximize cost savings.
    - Fixed discharge schedules fail to account for peak demand periods, leading to higher energy expenses.

4. Reliability & Safety Risks
    - Batteries can experience thermal runaway, faults, and inefficiencies, increasing the risk of fires, outages, and grid instability.
    - Manual monitoring is slow and reactive, failing to prevent failures before they escalate.

These challenges highlight the need for advanced AI/ML-based solutions to enhance BESS operations, reduce costs, and ensure long-term reliability.

1. AI/ML Applications for Enhanced Performance and Efficiency

How AI Benefits This Area:

BESS energy dispatch can rely on static rules or schedules, making it inefficient towards fluctuations and demand changes.

AI optimizes battery operation by analyzing real-time data from the grid, adjusting charge/discharge cycles, and predicting power demand.

- AI predicts energy demand patterns and schedules BESS operations efficiently.
- Optimizes power conversion and dispatch for maximum efficiency.
- Ensures minimal energy loss through intelligent load balancing.

Without AI, battery dispatch follows fixed schedules or rule-based algorithms, leading to inefficient energy use, increased losses, and failure to adapt to real-time grid conditions.

Key Applications:

1. State-of-Charge (SoC) & State-of-Health (SoH) Estimation – AI predicts degradation trends and usage patterns to optimize charge usage and State of Health.
2. Smart Cell Balancing – AI redistributes charge to prevent uneven wear across battery cells.
3. Self-Healing Algorithms – ML automatically corrects inefficiencies to extend battery lifespan.
4. Battery Degradation & Aging Prediction – AI predicts wear rates and adjusts operations to slow down degradation thereby extending battery life.
5. Load Profile Adaptation – AI learns user-specific consumption habits to optimize charging patterns.

Example: AI-Managed EV Fleet Battery Optimization

An electric bus fleet uses AI-driven SoH monitoring to predict battery degradation, extending fleet lifespan and reducing replacement costs.

2. AI/ML Applications for Extended BESS Battery Pack Usable Life

How AI Benefits This Area:

Batteries degrade over time due to charging cycles, temperature variations, and uneven cell utilization.

AI applies predictive maintenance and self-healing algorithms to extend battery lifespan, reducing replacement and operational costs.

- AI monitors battery health (SoC, SoH) in real-time and adjusts usage accordingly.
- Predicts degradation trends and adjusts charging strategies to slow aging.
- Balances cell loads dynamically to prevent overuse of specific cells.

Without AI, charge/discharge cycles operate on static parameters, causing uneven degradation, reduced lifespan, and increased maintenance costs due to lack of predictive optimization.

Key Applications:

1. Intelligent Charge & Discharge Management – AI optimizes charge/discharge schedules based on grid demand and battery health.
2. Dynamic Load Forecasting – AI predicts power demand trends to ensure efficient energy dispatch.
3. Thermal Management & Cooling Optimization – AI dynamically adjusts cooling mechanisms to prevent overheating.
4. Adaptive Charging Strategies – AI tailors charging rates based on battery chemistry and usage patterns.
5. AI-Optimized Demand Response – AI modifies BESS behavior based on grid signals to improve system efficiency.

Example: AI-Enhanced Smart Grid BESS Optimization

A smart city microgrid uses AI-driven BESS to dynamically adjust charge/discharge schedules based on real-time demand, reducing grid congestion and energy waste.

3. AI/ML Applications for Cost Savings and Grid Tied Optimization

How AI Benefits This Area:

Energy markets are highly volatile, and electricity prices fluctuate throughout the day.

AI enables cost-efficient energy trading, load shifting, and market participation, ensuring BESS owners maximize their return on investment (ROI).

- AI predicts price fluctuations and buys/sells energy at optimal times.
- AI-driven peak shaving reduces demand charges by optimizing discharge times.
- Microgrid BESS can autonomously transition between grid-connected and islanded operation.

Without AI, energy trading and load management rely on manual forecasting and fixed strategies, missing out on dynamic market opportunities and leading to higher energy costs.

Key Applications:

1. Energy Price Forecasting & Arbitrage – AI predicts electricity price fluctuations to optimize storing and selling energy.
2. Peak Demand Reduction & Load Shifting – AI forecasts peak loads and adjusts BESS discharge to lower demand charges.
3. Dynamic Energy Trading & Market Participation – AI allows BESS owners to participate in energy markets for optimized financial returns.
4. Smart Scheduling for Off-Grid & Remote Systems – AI optimizes BESS operation in microgrids, reducing reliance on costly diesel generators.
5. Autonomous Grid Islanding & Recovery – AI enables seamless transition between grid and islanded modes.

Example: AI-Powered Energy Trading for Industrial BESS

A factory BESS uses AI to monitor electricity prices, strategically charging when prices are low and selling energy during peak hours, saving annually on energy costs.

4. AI/ML Applications for Reliability and Safety Enhancement

How AI Benefits This Area:

Safety is a critical concern in BESS systems, as battery failures can lead to thermal runaway, fires, and system-wide failures.

AI provides anomaly detection, fault prediction, and autonomous grid stabilization, reducing operational risks.

- AI detects thermal runaway risks in advance, preventing catastrophic failures.
- AI predicts grid faults and takes preventive actions before system failures occur.
- AI stabilizes voltage and frequency fluctuations autonomously.

Without AI, fault detection and anomaly prediction are reactive rather than proactive, increasing the risk of unexpected battery failures, thermal runaway incidents, and costly downtimes.

Key Applications:

1. Real-Time Anomaly Detection & Fault Diagnosis – AI detects V, I, and T irregularities to prevent failures.
2. Failure Prediction & Preventive Maintenance – AI predicts equipment failures, reducing downtime and costly repairs.
3. Grid Frequency & Voltage Regulation – AI adjusts power injection to stabilize frequency and voltage fluctuations.
4. Blackout Prevention & Resilience Enhancement – AI enhances resilience by proactively responding to grid events.
5. Predictive Grid Support & Ancillary Services – AI enables BESS to provide reactive power, frequency regulation, and inertia support.

Example: AI Predictive Maintenance for Utility-Scale BESS

A utility-scale BESS uses AI-powered fault detection, predicting thermal runaway risks days in advance, preventing catastrophic failures and ensuring grid stability.

Summary of AI/ML Benefits for BESS

- Battery Energy Storage Systems (BESS) play a crucial role in modern energy infrastructure, balancing supply and demand, integrating renewables, and ensuring grid reliability.
- However, managing BESS efficiently is a complex challenge due to nonlinear battery behavior, degradation over time, unpredictable energy demand, and grid fluctuations.
- AI and ML offer unparalleled advantages in handling these complexities, enabling real-time optimization, predictive analytics, and autonomous decision-making.

Category	Key Applications
Enhanced Performance & Efficiency	AI-driven charge/discharge management, load forecasting, cooling optimization
Extended Battery Life	Smart cell balancing, self-healing algorithms, SoH estimation
Cost Savings & Grid Optimization	AI-based energy trading, peak demand reduction, autonomous islanding
Reliability & Safety Enhancement	Anomaly detection, failure prediction, blackout prevention

Key Applications for BESS in each Category

Our Mission & Vision

To bring together an ***interdisciplinary team of researchers, industry partners and community*** *to address challenges in energy, power, environment and policy making: design & develop inventive solutions, to* ***train next generation professionals with industry and state collaboration*** *on education and research.*

EPSi Group is aspiring to bring clean, efficient, sustainable, and safe energy solutions to its clients, strengthening the inter-dependencies between critical infrastructure elements.

FIU
Energy, Power & Sustainability

Academics & Research

- Student pathways for job and workforce training in distribution center and edge device technologies.
- New Masters in Energy & Cybersecurity program launched
- More than $ 10 Million funding in last 4 years
- About 50 Students, Post-Doctorate Scholars & Researchers
- Multiple Outreach Activities, Publications, Seminars & Courses
- Top collaborators: NREL, DOE, NSF, GE, FPL/NextEra

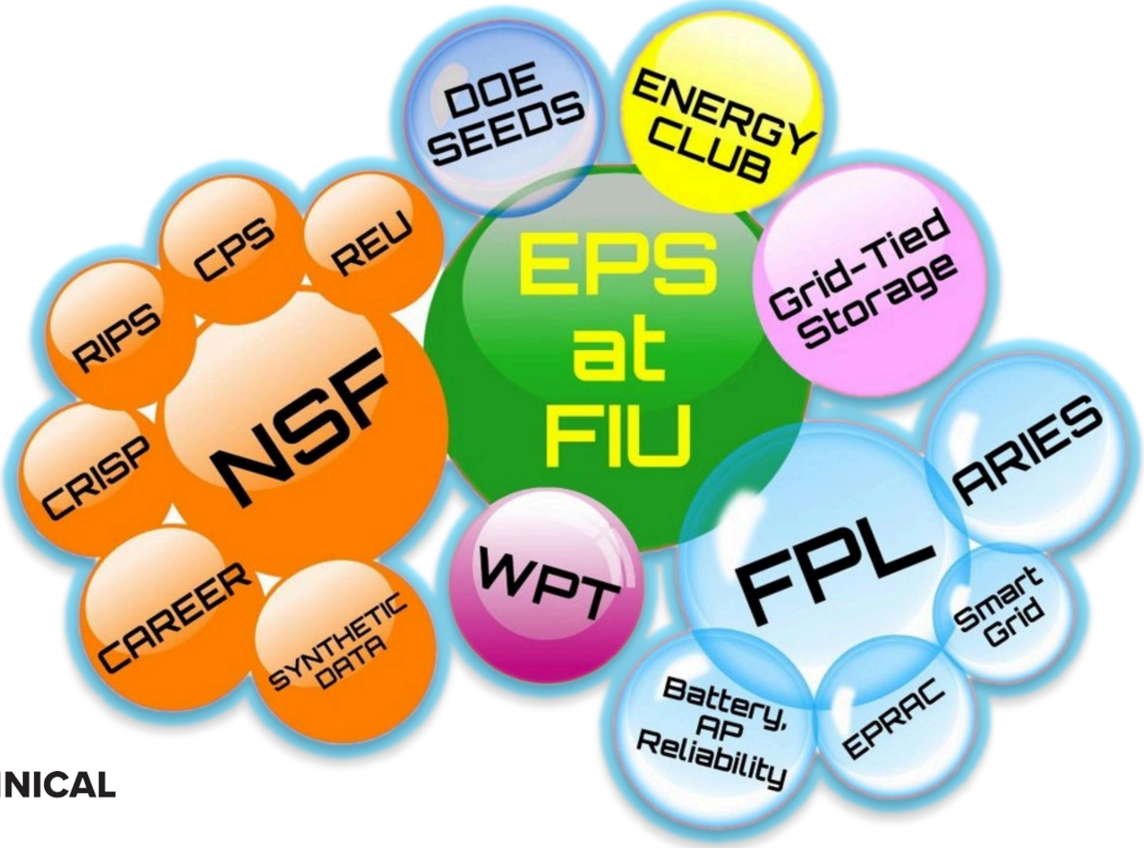
& Other Universities

- Almost all students get jobs before or within 3 months

of graduations

- Internships at leading companies and labs

Electric Power Grid	AI-Based Renewable Microgrid	Wireless Power Transfer	Real-Time Simulation	Smart City Initiatives



NSF · U.S. Department of Energy · NextEra Energy Resources · INL Idaho National Laboratory · Prologis · NREL · FPL · Oak Ridge National Laboratory · General Electric · Argonne National Laboratory · NNSA National Nuclear Security Administration · NTU Navajo Technical University

FPL/FIU Renewable Microgrid

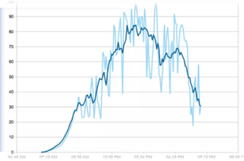
FPL · NEXTera ENERGY · FIU Energy Power & Sustainability, Florida International University

- Grid-Tied **3 MW/ 09 MWh Battery Energy Storage Plant** connected with **1.4 MW PV Power Plant on Campus**
- Battery Storage System would consist of Batteries with Battery Management System and Smart Inverters
- FIU **Photovoltaics would charge the battery**, which would ultimately be used to power up the Engineering Center
- Microgrid would **operate in Islanded mode**. In grid connected mode, Feeders would serve FIU EC directly

Design and Operation

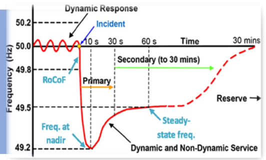
- Microgrid Operational Dynamics
- Process and Standards Recommendation
- Smart Inverter Settings Development
- Motor Loads Reliability Impact Analysis

Distribution Solar Smoothing and Integration



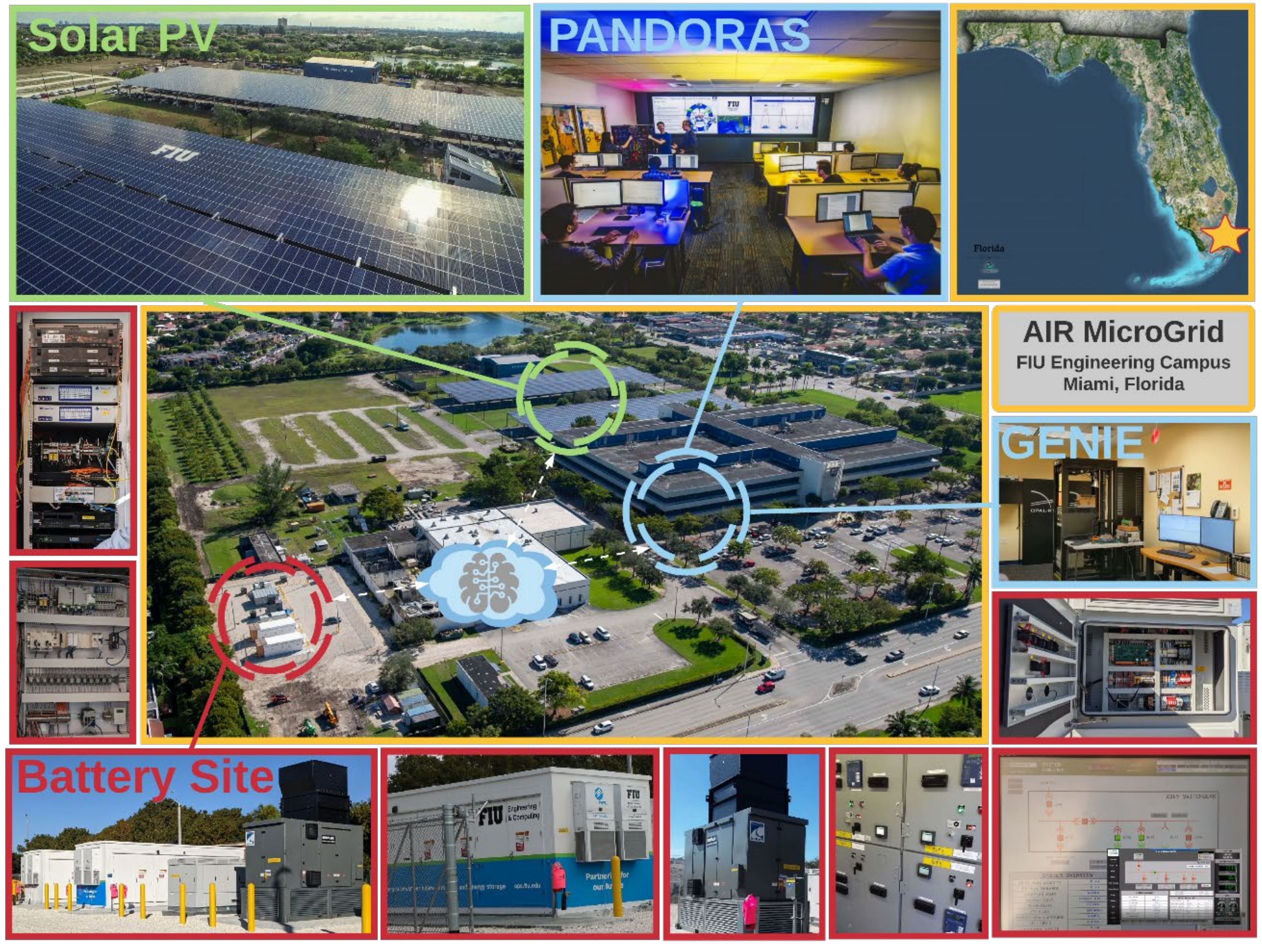
Battery Health and Capacity Degradation

Frequency Response and Virtual Inertia



Grid Support Analysis

U.S D.O.E defines Microgrid as "*a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.*"



Real-Time Simulation Lab

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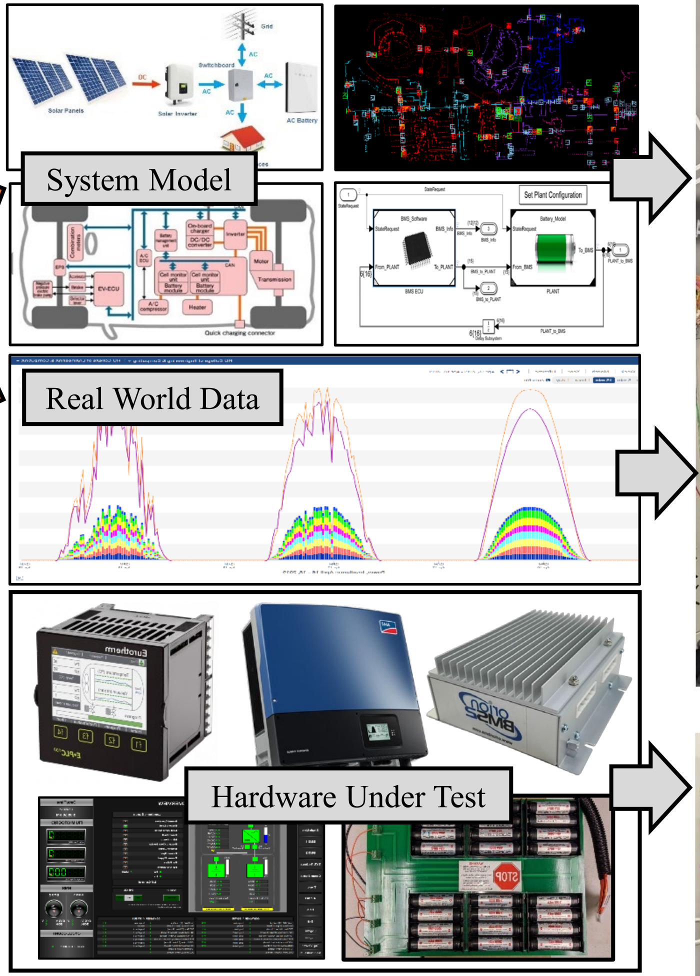
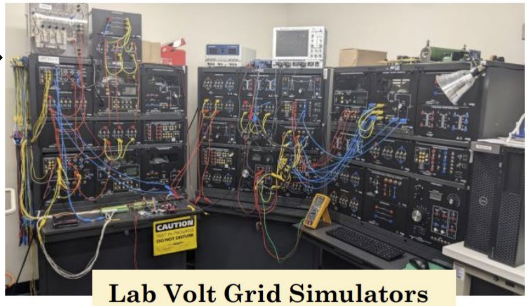
GENIE lab can model and simulate actual power systems in real time using real world data in order to design and validate hardware controllers and machine learning algorithms for increased reliability and resiliency.

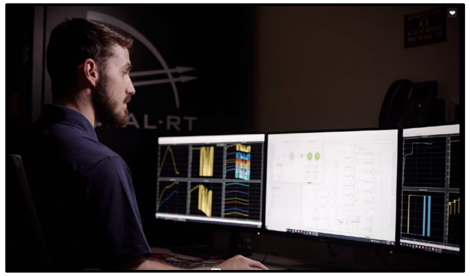
- Modeling of AIR Microgrid electronic components, and electric vehicles.
- Standard industry simulation software such as MatLab/ Simulink
- Implements standard communication protocols for high modularity.



Real-Time Simulators



Lab Volt Grid Simulators



PANDORAS

Connectivity between the **Proactive ANalytics and Data-Oriented Research on Availability & Security (PANDORAS)** Lab and the **Grid ENergy Intelligence and Exploration(GENIE)** Lab allows EPSi students the ability to seamlessly control real-time emulated systems for command and control room operations.

Continuing Long Term Partnership with Industry

Countless Connections…

Past Students

Name	Program	Date of Completion	Currently Working At
Dr. Haneen Aburub	PostDoc	Fall 2018	Instructor, ECE Department, FIU
Dr. Amir Moghadasi	PostDoc	Fall 2017	Lead Traction Power Engineer, WSP USA, Oakland CA
Longfei Wei	PhD	Fall 2018	Power System Engineer, GEIRINA USA, San Jose CA
Masood Moghaddami	PhD	Fall 2018	Senior Electronics Engineer, Acuity Brands, Decatur GA
Imtiaz Parvez	PhD	Fall 2018	Working with FIU, Miami FL
Amir Moghadasi	PhD	Summer 2016	Continued with Post-doctoral position at EPS Group, FIU, Miami FL
Arash Anzalchi	PhD	Fall 2017	Engineering Manager at Colite Technologies, Columbia SC
Aditya Sundararajan	PhD	Fall 2019	Continued with PhD at EPS Group, FIU, Miami FL
Mahdi Jamei	MS	Fall 2014	Continued with PhD at Arizona State University
Yemeserach Mekonnen	PhD	Fall 2019	John Hopkins Physics Lab
Sophie Mugomoka	MBA	Spring 2017	Global Privacy Analyst, Northrop Grumman, Washington DC
Jonathan Pinto	MS	2016	Working with the utility
Danish Saleem	MS	2016	National Renewable Energy Laboratory, Golden CO
Harikrishnan T Nair	MS	2017	Senior Electrical Engineer, Agtronix, Naples FL
Ipsita Acharya	MS	Fall 2018	Senior Engineer, Quest Global, Houston TX
Tanwir Khan	MS	Spring 2018	Data Analytics Consultant, PwC, Miami FL
Farhan Khayum	MS	Spring 2015	Automation Engineer, Aztec Technologies, Lawrence MA
Jide Lu	MS	Spring 2017	Continued with PhD at FIU
Samira Zad	MS	2017	Continued with PhD at FIU
Elaheh Zarafshan	MS	2017	Continued with PhD at FIU
Philip Stankovic	MS	2015	**Florida Power and Light (FPL)**
Maneli Malek Pour	MS	2014	**Florida Power and Light (FPL)**
Prashant Akhade	MS	2017	Associate-Systems, Synechron Technologies Pvt. Ltd., Miami FL
Anjali Tripathi	MS	Spring 2017	Systems Engineer I, Beckman Coulter, Miami FL
Avinash Jeewani	MS	Fall 2018	AICINEXT as Machine Learning Engineer, Boca Rtaon
Mohammad Asif Khan	MS	Spring 2020	Icast, Miami FL
Aditya Tiwari	MS	Summer 2019	Korbyt, Texas, Dallas
Jonathan Sarochar	MS	MS	FPL
Sebastian Barrera	BS	Spring 2018	Continued with MS at FIU, Miami FL
Dailys Aparicio	BS	Fall 2018	**Florida Power and Light (FPL)**
Salvador Salinas	BS	Fall 2018	**Florida Power and Light (FPL)**
Jose Ingaluque	BS	Fall 2018	**Florida Power and Light (FPL)**
Ivan Alvarez	BS		**Florida Power and Light (FPL)**
Rolando Gonzalez	BS	Spring 2017	Drone Researcher, University of Miami, Miami FL
Fernando Lozada	BS	Spring 2017	Associate Engineer, San Diego Gas & Electric, San Diego CA
Salman Hamid	BS	Spring 2017	**Florida Power and Light (FPL)**
Dave Scott	BS	Spring 2019	
Carlos Falkenhagen	BS	Spring 2019	
Radames Sanchez	BS	Spring 2019	
Sheikh Islam	BS	Spring 2019	
Andres Gomez	BS	Fall 2018	
Andrew Martinez	BS	Fall 2018	
Reginald Sylney	BS	Fall 2018	
Carlos Sarria	BS	Fall 2018	
Kristian Porro	BS	Fall 2018	
Arthur Carbonell	BS	Fall 2018	
Kristhiam Granados	BS	Fall 2018	
Rigel Prieto	BS	Spring 2019	
Yader Mendieta	BS	Spring 2019	
Sanz Johnson	BS	Spring 2019	

Name	Program	Date of Completion	Currently Working At
Sebastian Albaraccin	BS	Spring 2017	Application Engineer, ABB, Miami FL
Glenda Gonzalez	BS	Spring 2017	**Florida Power and Light (FPL)**
Enrqiue Espinet	BS	Fall 2018	**Florida Power and Light (FPL)**
Maria Paula Ariza	BS	2018	**Florida Power and Light (FPL)**
Manuel Guiterrez	BS	Spring 2017	**Florida Power and Light (FPL)**
Garrett Siljee	BS	Spring 2017	**Florida Power and Light (FPL)**
Hector Pena Perea	BS	Spring 2016	**Florida Power and Light (FPL)**
Carlos Rodriguez	BS	Spring 2016	**Florida Power and Light (FPL)**
Patrick Vega	BS	2016	**Florida Power and Light (FPL)**
Andres Cavada	BS	2016	**Florida Power and Light (FPL)**
Jason Hernandez	BS	2016	**Florida Power and Light (FPL)**
Raul Nelson Centeno	BS	2017	**Florida Power and Light (FPL)**
Lourdes Badaracco	BS	2016	**Florida Power and Light (FPL)**
Victo Valencia	BS	2016	**Florida Power and Light (FPL)**
Nelson Velasro	BS	2016	**Florida Power and Light (FPL)**
Diocles Torralbas	BS	2016	**Florida Power and Light (FPL)**
Orlando Gutierrez	BS	2017	**Florida Power and Light (FPL)**
William Shane	BS	2017	**Florida Power and Light (FPL)**
Steven Lee	BS	2017	**Florida Power and Light (FPL)**
Unior Rodriguez	BS	2017	**Florida Power and Light (FPL)**
Javier Cusicanqui	BS	2016	Continued with MS at FIU, Miami FL
Cory Hunter	BS	2017	System Engineer, Northrop Grumman, Miami FL
Tony Maturana	BS	2017	**Florida Power and Light (FPL)**
Louis Medina	BS	2017	**Florida Power and Light (FPL)**
Joshua Eisenberg	BS	2015	Continued with PhD at FIU
Zeiada Aziz	BS	2014	**Florida Power and Light (FPL)**
Alain Grande	BS	2017	**Florida Power and Light (FPL)**
Alexander Hernandez	MS	Fall 2018	
Asim Nabi	MS	Spring 2019	Amzur Technologies
Alireza Entessari	MS	Summer 2019	
Juan Sanfiel	MS	Spring 2020	Pike Utility
Roberto Sanchez	BS		
Edward Sanchez	BS		
Jamie Sanchez	BS		**Florida Power and Light (FPL)**
Elda Potter	BS		
Aldo Egas	BS		
Reynier Serpa	BS		
Fayyaad Razak	BS		
Yader Mendieta	BS	Spring 2019	
Sanz Johnson	BS	Spring 2019	
Shamini Dharmasena	PhD	Fall 2018	
Hassan Jafari	PhD	Fall 2018	Rivian
Mohammed Aquib	MS	Fall 2021	
Iffat Alam	MS	Fall 2021	
Asham Amir	MS	Fall2021	
Luanna Ochoa	BS	Fall 2017	
Alejandro Valle	BS	Fall 2018	Florida Power and Light (FPL)
Gabriela Nunez	BS	Fall 2018	Florida Power and Light (FPL)
Daniel Aldecoa	BS	Fall 2018	Florida Power and Light (FPL)
Gabriel Madrid	BS	Fall 2018	Florida Power and Light (FPL)
Darien Walker	BS	Spring 2019	
Moises Olivier Lauture	BS	Spring 2019	
Erney Lorquet	BS	Spring 2019	
Jordan Lewis	BS	Fall 2018	

Current Students

Name	Program	Date of Joining
Hugo Riggs	Post Doc	Fall 2018
Mohd Tariq	Post Doc	Fall 2022
Temitayo Olowu	Post Doc	Fall 2017
Asadullah Khalid	Post Doc	Spring 2018
Anjan Debnath	Post Doc	Fall 2019
Sukanta Roy	PhD	Fall 2021
Alexander Stevenson	PhD	Fall 2020
Abdul Shakir Khan	PhD	Spring 2023
Hasan Iqbal	PhD	Spring 2023
Milad Behnamfar	PhD	Spring 2022
Abu Taher	PhD	Fall 2022
Erandy Dominguez	BS	Summer 2024
Miguel Gonzalez	BS	Summer 2024
Roberto Diaz	BS	Summer 2024
Nicolas Haage	BS	Summer 2024
Praveen Gulla	MS	Spring 2024
Muttahar Khalid	MS	Spring 2024
Jawad Muhammed	MS	Spring 2024
Arif Muhammed	MS	Spring 2024
Sriram rao Chennamaneni	MS	Fall 2022

100 + *Graduated Students*

98% *Finding Jobs **Before** Graduating*

30 + *Student Achievement Award*

20 + *Current Students*

5 *FIU **Worlds Ahead** Graduates*

And Many More…

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