Electric Power and Energy Systems Engineering Program – An Overview

Raja Ayyanar

ASU electric power and energy systems program

- ASU has the one of the largest electric power and energy systems programs in the country today
- Relative to other universities, we are the most diverse in terms of research expertise, simulation tools, and experimental capabilities
- ASU's program is among the top three programs in the nation in research excellence and recognition (has 3 National Academy of Engineering members)
- Our graduates have an excellent record with employers and also in graduate school
- Excellent employment opportunities – it is difficult to '*outsource*' power engineering

Power Area Faculty Members

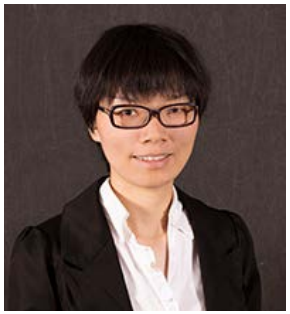
Raja Ayyanar

Kory Hedman

Gerald Heydt

Keith Holbert

Mojdeh Khorsand Hedman



Qin Lei

Anamitra Pal

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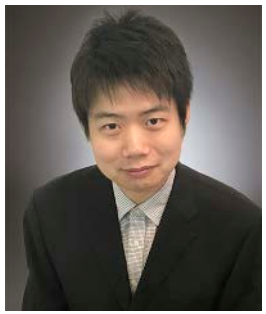
Lalitha Sankar

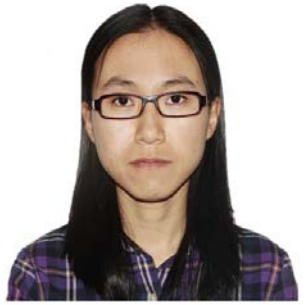
Daniel Tylavsky

John Undrill

Vijay Vittal



Yang Weng



Meng Wu

Employment in power engineering

- Within the next decade the electric power industry will, of necessity, engage in large infrastructure development, especially in the development of renewable energy resources
- In addition, estimates are that 50% of the utility engineering workforce will retire within 10 years
- The availability of U.S. trained engineers will be insufficient to meet the needs of the industry

Undergrad power courses

EEE 360 Energy Systems and Power Electronics

EEE 460 Nuclear Power Engineering

EEE 463 Electrical Power Plants

EEE 470 Electric Power Devices

EEE 471 Power System Analysis

EEE 472 Power Electronics

EEE 473 Electrical Machinery

EEE 488-489 Senior Design Projects

All of these courses except EEE473 are also offered as internet and hybrid courses

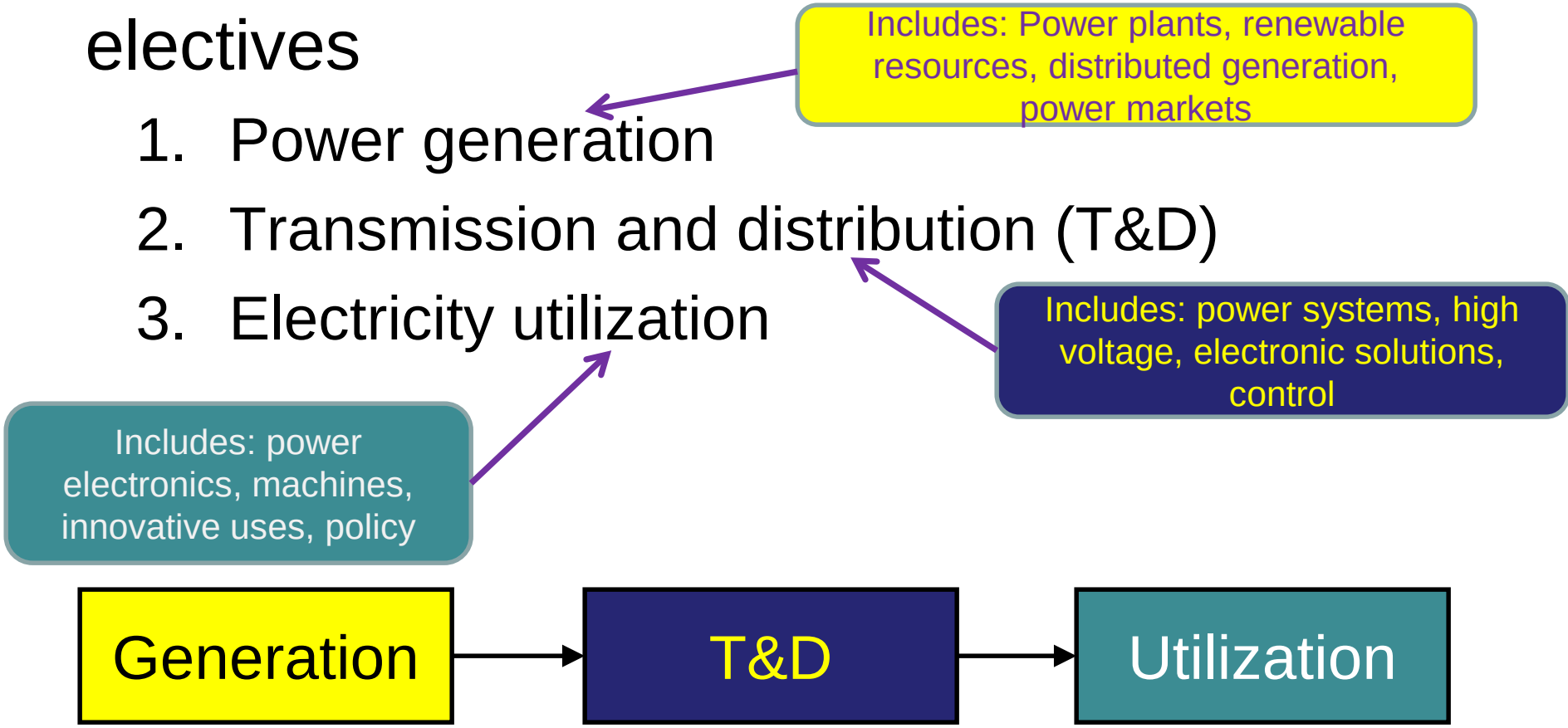
Concentration in electric power and energy systems

Requirements for the concentration are

- EEE 360 Energy Systems and Power Electronics (4)
- At least 9 hours of electrical engineering technical electives in the power and energy area, which may include any combination of the following courses:
  - EEE 46x/47x and approved EEE 498 special topics courses (e.g., Solar Energy), and
  - At most one of either IEE 300 or 431;
- A capstone senior design project (EEE 488 + 489) in the EPES field of study as approved by the EE Associate Chair for Undergraduate Studies.

Power senior technical electives

- What power courses should you take?
- Three subdivisions of the power technical electives
  1. Power generation
  2. Transmission and distribution (T&D)
  3. Electricity utilization

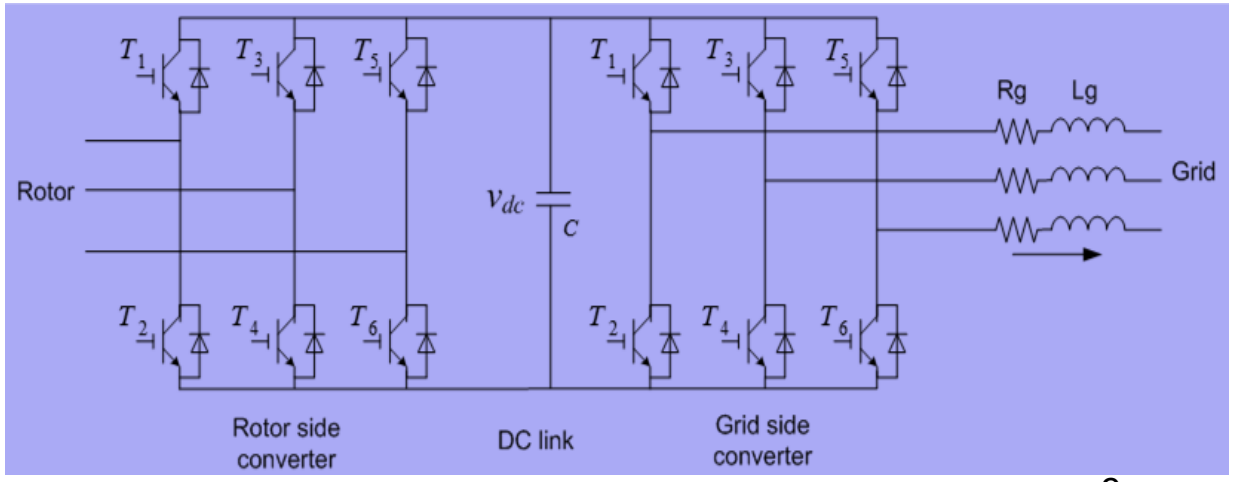


Aircrafts and ships are mobile power systems (all three power area subdivisions)

Renewable energy

Possibly the most **transformative** factor in future power and energy systems

Two types of solar energy: **photovoltaic** and **concentrated solar**



1. Power generation

- EEE 463 Electrical Power Plants
  - Generation of electric power using fossil, nuclear and renewable (including solar, geothermal, wind, hydroelectric, biomass and ocean energy sources). Power plant thermal cycle analysis. Cogeneration and combined cycles. Economics, operations, and design of electric power stations. Energy storage.
- EEE 460 Nuclear Power Engineering
  - Radioactivity and decay. Radiation interactions and dose. Nuclear reaction, fission and fusion theory. Fission reactors, four factor formula, moderation. Nuclear power, TMI, Chernobyl. Nuclear fuel cycle.

Students are attracted to power engineering because they like to work on *important things* – it is NOT ALL THEORY

2. Transmission and distribution

- EEE 470 Electric Power Devices
  - Analyzes devices used for short circuit protection, including circuit breakers, relays, and current and voltage transducers. Protection against switching and lightning over voltages. Insulation coordination.
- EEE 471 Power System Analysis
  - Review of transmission line parameter calculation. Zero sequence impedance, symmetrical components for fault analysis, short circuit calculation, review of power flow analysis, power system stability, and power system control concepts.

Power Electronics (fast switches)

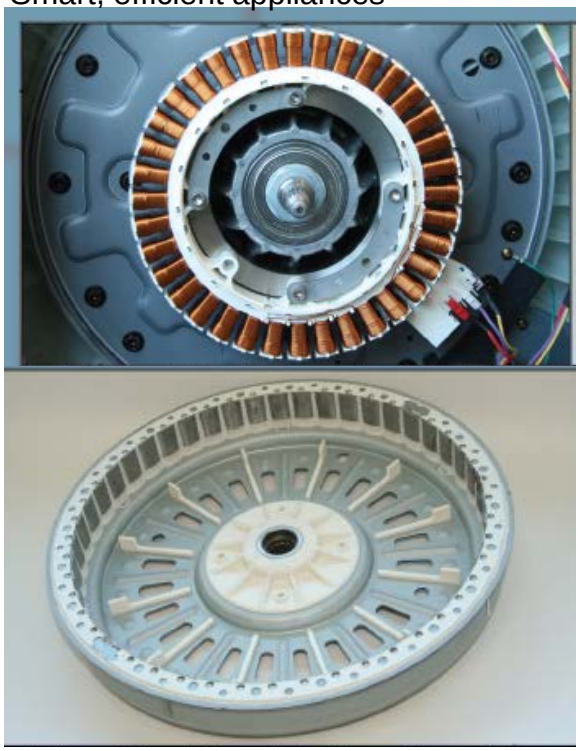
Google data center

DC/DC, AC/DC and DC/AC converters with power semiconductor devices

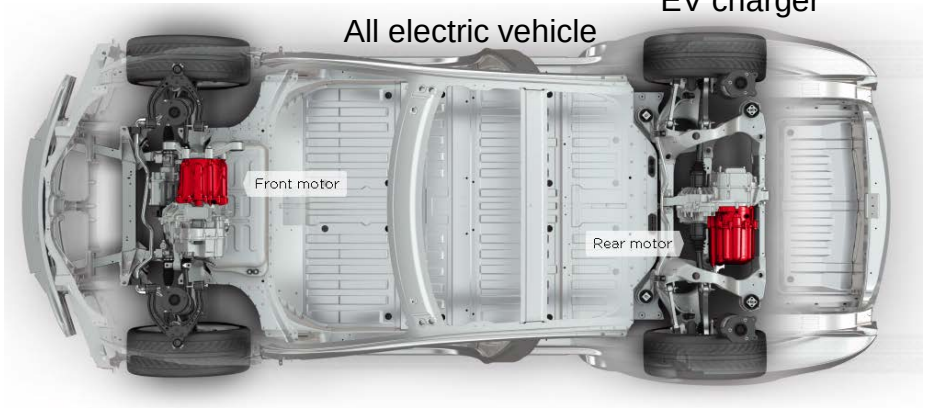
Modern LED lighting

EV charger

Smart, efficient appliances



All electric vehicle



3. Electric energy utilization

- EEE 472 Power Electronics
  - Fundamentals of power electronics, design-oriented analysis of power electronic converters, PLECS based simulations, modern applications including powering information technology, electric vehicles, renewable interface
- EEE 473 Electrical Machinery
  - Operating principles and modeling of electric machines including DC, brushless DC, induction, permanent magnet and conventional synchronous machines; control aspects of these machines within electric drives for industry automation, energy conservation through variable speed drives, wind generators and electric vehicles.

A paradigm shift for the power industry

Today

Centralized generation

Paradigm shift

FREEDM system

Distributed renewable energy resources (DRER)

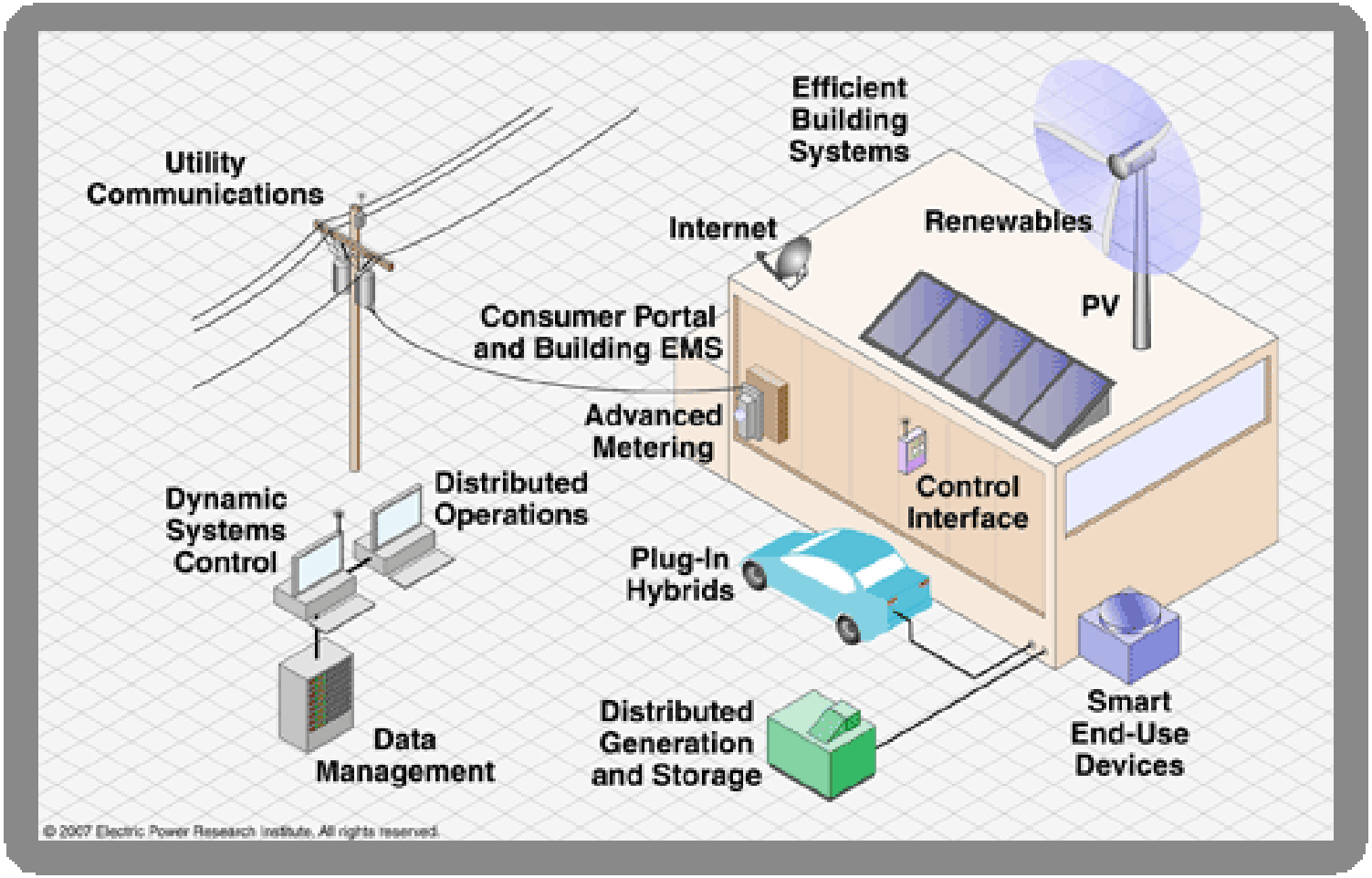
- **Ubiquitous sales**
- **Ubiquitous ownership**
- **Ubiquitous use**
- **Ubiquitous sharing**

Innovation and industry transformation

New technologies for distributed renewable energy

New energy companies based on IT and power electronics technologies

Evolution of the smart grid



The Smart Grid is a concept that maximally uses digital technology, sensory information, electronic controls, and innovative and integrated energy infrastructures.

Several large research centers at ASU

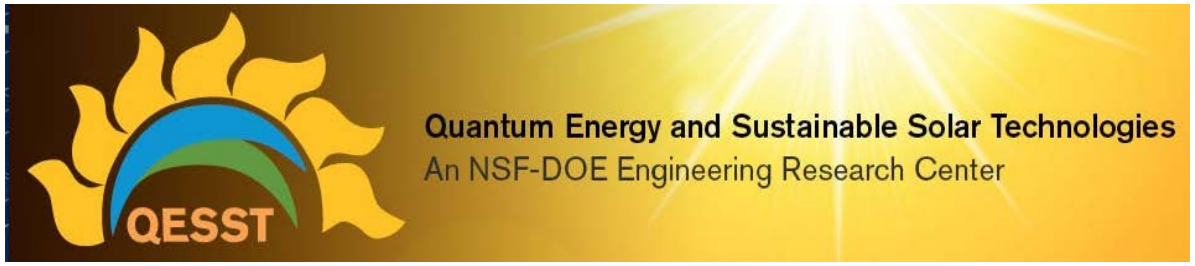
http://pserc.wisc.edu/

- Power Systems Engineering Research Center
- ‘Collaboratory’ of 13 universities
- ASU is the lead university
- Markets, T&D, and Power Systems
- About 40 collaborating researchers
- Industry and NSF supported
- Projects in all areas of power engineering

www.freedm.ncsu.edu

- NSF supported ERC
- Based at NCSU
- ASU is a partner university
- Focuses on advanced distribution engineering
- Solid state control of power and energy

An ASU led research center focusing on photovoltaics (PV) and advanced energy converters.



Several large research centers at ASU

POWERAMERICA

https://www.poweramericainstitute.org/

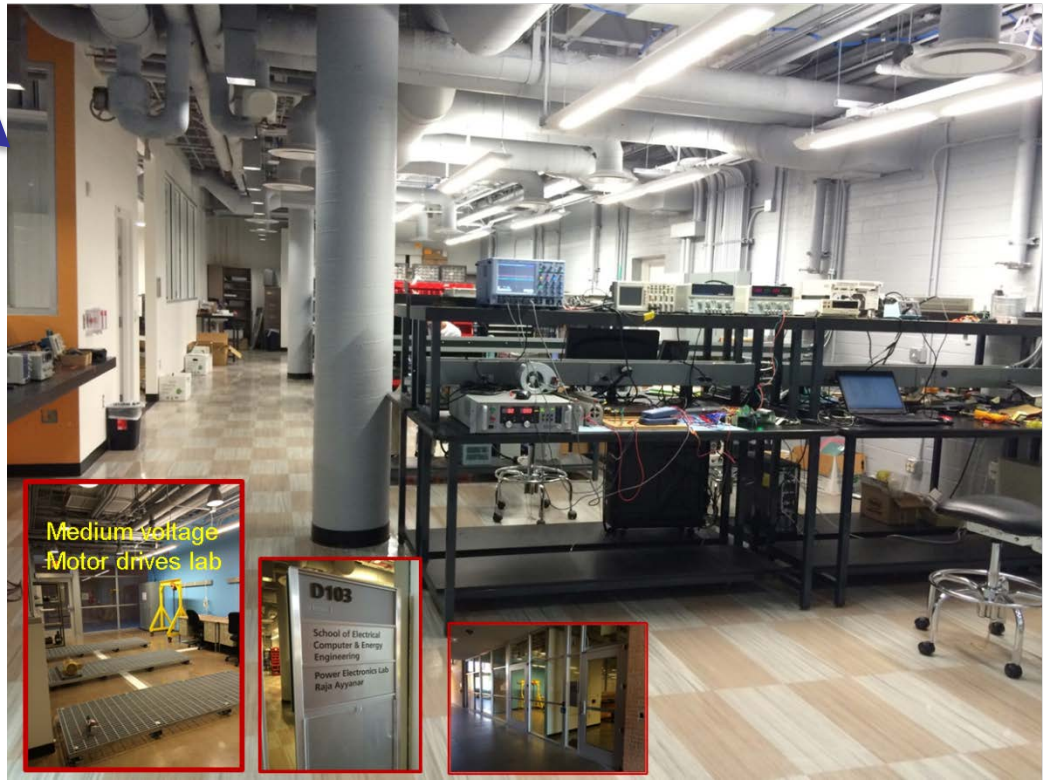
A research center for the development and manufacturing of wide bandgap semiconductor devices for the power industry and innovative applications ASU is a partner university of the center led by NCSU

GEARED

Grid Engineering for Accelerated Renewable Energy Deployment: A US Department of Energy educational program in power engineering. ASU is a partner university in a center led by EPRI.

Power laboratories

- High Voltage Lab
- Power Electronics Lab
- Electronic Control of Power Systems
- Power System Simulation Lab
- Instrumentation Lab
- Fiber Optic Cable Aging Test Facility



Questions

Answers