Center for Energy Systems

Skolkovo Instititute of Science of Technology

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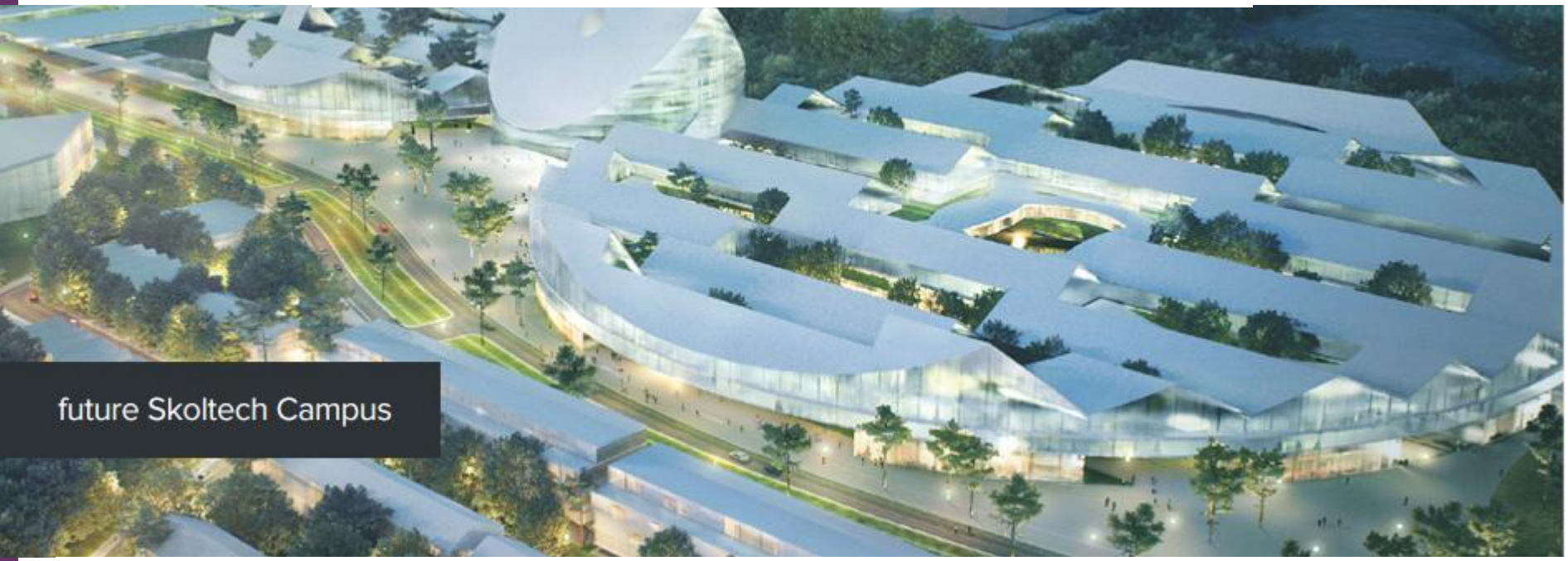
In collaboration with Massachusetts Institute of Technology



New private, graduate university based on MIT model

Key concept: combined Research, Education and Innovation

15 multidisciplinary Centers for Research, Education and Innovation (CREI)

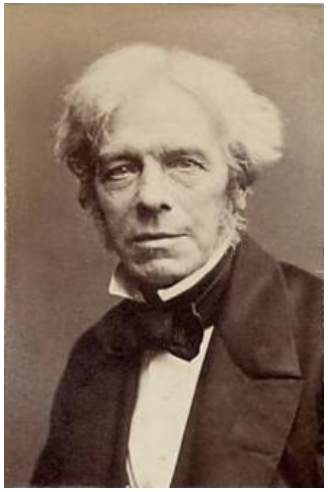
Energy, BioMed, IT, Space, Nuclear,

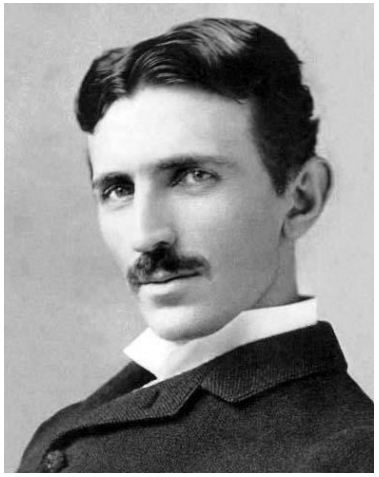
World-class research leading to applications

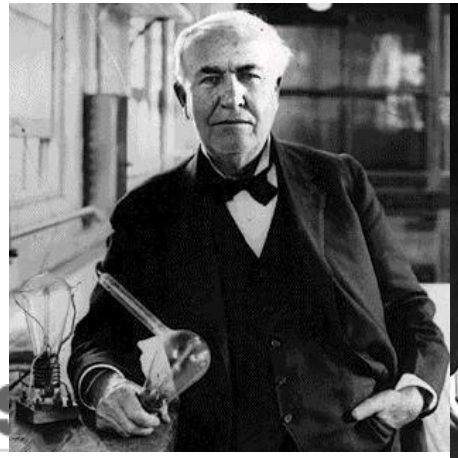
International collaboration

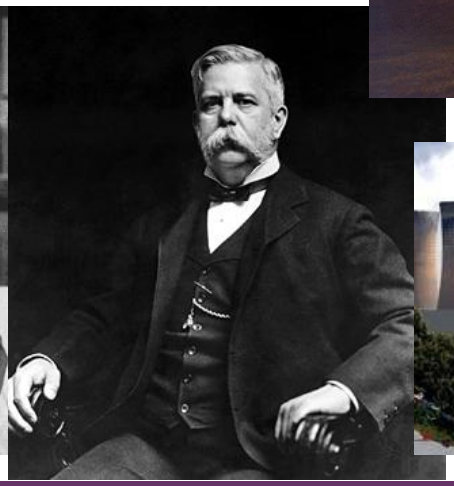
Power System in 20th Century

19th Century science + 20th Century technology



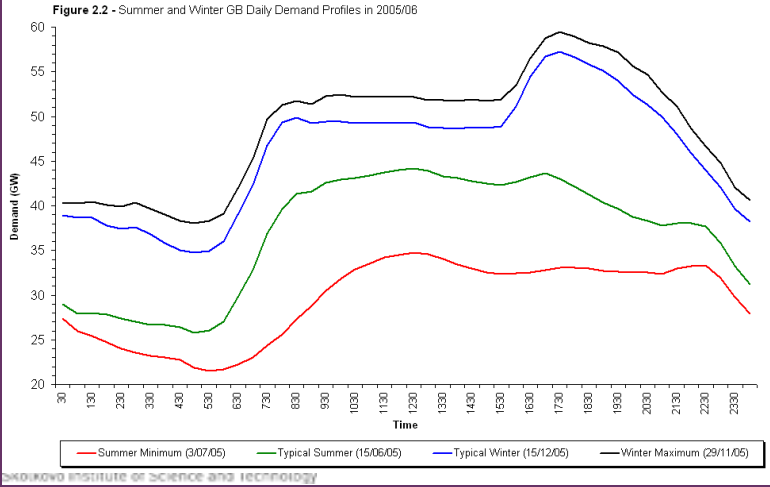






Power system in the 20th Century

- Feat of engineering: very reliable
- Centralised control of a limited number of large controllable power stations
- Predictable and passive demand
- Design and operation
  - Deterministic (N-1)
  - Designed to serve peak load – low asset utilisation (55% Gen., 30% Transm.)
  - Passive distribution: “install and forget”



Drivers for change in 21st Century

- Climate change
- Growth of distributed (renewable and fossil-fuel), uncontrollable and stochastic power generation
- Active and stochastic distribution level (prosumers):
  - Demand participation
  - PV
  - Electric vehicles

Change of paradigm

- 20th Century: centralised control by System Operator of a limited number of controllable power stations to meet a deterministic demand
- 21st Century: distributed control of a very large number of uncontrollable and stochastic power sources to meet a stochastic demand
- How to accommodate the changes?

Power System in 21st Century

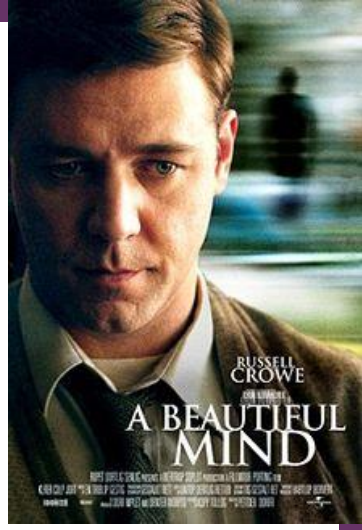
19th Century science + 20th Century technology

+ 21st Century ICT

New control tools and methodologies needed

General aim: create a cyber-physical power system able to deal with the challenges.

Whole-system, interdisciplinary approach needed



- Mathematics, computer science
  - Distributed, stochastic control
- Physics
  - Large-scale dynamic object
- Economics
  - Markets, regulation
- Social science
  - Understanding the customers
- Politics
  - Approval of the electorate
- Engineering
  - Understanding the physical power system

Key drivers and challenges in Russia

- Technical challenges:
  - Spatial extent: 9 time zones.
  - Strong coupling, due to the climate and district heating, between interdependent infrastructures (power, gas, heat) – poorly optimized.
  - Semi-autonomous systems in Arctic and Far East.
- Growth and maturing of renewables.
- Russian power industry has great traditions but has not kept up with modern developments.
  - Aging Infrastructure.
  - Poor efficiency and threatened reliability.
  - Generational/technological change.
- Rapid market reforms creating inefficiencies.

Skoltech Center for Energy Systems

Main partners:

- IES RAS (Irkutsk), Novosibirsk and others
- MIT, Caltech, US National Labs, Michigan, Comillas (Spain), Newcastle (UK)

Main industrial partners: Rosseti, Federal Grid Company, System Operator, En+ et al.

Four main thrusts

1. Smart and Resilient Grids
2. Energy Markets and Regulation
3. Coupled Energy Infrastructures
4. Power Electronics and Devices

Thrust #1: Energy Markets and Regulation

- **Aim:** Improve efficiency of the markets.

- **Grand challenges for Russia:**
  - Incentivize modernization of the power generation fleet (capacity market)
  - Develop integrated pricing mechanism of electricity and heat.
  - Promote energy conservation and sustainability
  - Develop effective Demand Side Response

Thrust #2: Smart and Resilient Grids

- **Aim:** Improve operation, control and planning of the power system.

- **Grand Challenges for Russia:**
  - Develop distributed power system control and management systems: smart active-adaptive grid
  - Improve emergency control systems.
  - Microgrids: develop multi-domain modelling, simulation and control algorithms
    - Integration of renewable energy sources

Thrust #3: Coupled Energy Infrastructures

- **Aim:** Improve joint efficiency and reliability of interdependent energy infrastructures (power, gas & heat).

- **Grand Challenges for Russia:**
  - Optimize operation, network reinforcement and expansion of coupled infrastructures
  - Develop interconnection projects
    - Far East Asia energy ring
    - Global Grid.

Thrust #4: Power Electronics and Devices

- **Aim:** Improve efficiency, reliability and resilience of power generation, conversion and supply.
- **Grand Challenges for Russia:**
  - Ultra-efficient power electronics conversion
  - Non-intrusive power use monitoring
  - Cyber-security: architecture and circuits for secure computation on grid data.
  - Generation: improved systems for waste heat recovery, associated gas utilization, flue gas cleaning and energy recuperation.

Opportunities

- Vacancies at all levels: PhD, postdoc, faculty
- Engage in world-class research relevant to Russia
- Excellent funding and benefits
- Opportunity to spend a significant amount of time working with foreign partners: MIT, Caltech, Michigan, US Federal Labs, Comillas, Newcastle