



# HYDROGEN ENERGY: PRODUCTION, STORAGE, TRANSPORTATION AND SAFETY

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**INTENDED AUDIENCE :** UG, PG and PhD students from Chemical Engineering, Mechanical Engineering, Energy Science, Energy Engineering, Energy Systems Engineering disciplines, however it is open to all those interested; faculty and industry personnel interested in hydrogen energy

**INDUSTRY SUPPORT :** Oil and Gas PSUs, Renewables based industries, Energy systems related industries

### COURSE OUTLINE :

The course will comprehensively cover all the aspects of the hydrogen energy value chain including production methods from hydrocarbons & renewables, separation & purification, storage, transportation & distribution, refueling, utilization in various sectors, associated energy conversion devices, sensing and safety. Technical comparisons of various processes and technologies, economic aspects & cost analysis, regulations, codes and standards, global status and future directions will be discussed. The course will provide a broad knowledge of hydrogen as an energy carrier, the way it will play an important role in various sectors towards decarbonization, current limitations and future scenarios.

### ABOUT INSTRUCTOR :

Prof. Pratibha Sharma is a Professor in the department of Energy Science and Engineering (DESE) at IIT Bombay. Her research interest lies in the field of hydrogen energy specifically solid state hydrogen storage materials, storage systems design and development for various applications. She is leading several multi-institutional projects on hydrogen where several other IITs, industries and research organisation are collaborating. She has several international collaborations and also established a multi-institutional R & D centre on Hydrogen at IIT Bombay. At IIT Bombay she has established four different research laboratories: (i) Hydrogen Storage Lab, (ii) DST- IIT Bombay Energy Storage Platform on Hydrogen (ESPhy), (iii) Energy Materials Synthesis Lab and (iv) Hydrogen Systems and Application Lab (HySAL). She has been teaching the course on Hydrogen Energy (EN 610) since 2010.

### COURSE PLAN :

**Week 1 :** Properties of hydrogen, global status of supply and demand, methods of hydrogen production, steam reforming, tutorial

**Week 2 :** Advanced methods of steam reforming, partial oxidation, autothermal reforming, combined reforming, reforming using alternate energy sources, tutorial

**Week 3 :** Hydrogen production from methane decomposition, from coal and biomass, tutorial

**Week 4 :** Hydrogen separation and purification, thermochemical cycles for hydrogen production, fundamentals for electrolysis of water

**Week 5 :** Components of electrolytic cell, configuration of electrolyzer stack, different electrolyzer technologies, photoelectrochemical hydrogen production, technical and economic comparison of different production methods and global status, cost analysis, tutorial

**Week 6 :** Introduction to hydrogen storage, underground hydrogen storage, fundamentals of hydrogen compression and expansion

**Week 7 :** Mechanical and non-mechanical hydrogen compressors; compressed hydrogen tank types and design considerations, tutorial

**Week 8 :** Hydrogen liquefaction, liquid state hydrogen storage tanks, fundamentals of hydrogen storage in adsorption based materials

**Week 9 :** Fundamentals and thermodynamics of absorption based hydrogen storage, metal hydrides, types of metal hydrides, metal hydride based systems design, tutorial

**Week 10 :** Novel materials for solid state hydrogen storage; economics of storage; Long distance hydrogen transport via pipelines, ships and in form of LOHC; hydrogen transport via road; hydrogen refueling stations

**Week 11:** Use of hydrogen in internal combustion engines, fuel cells, hydrogen sensing

**Week 12 :** Properties of hydrogen associated with hazards, classification of hydrogen hazards, compressed and liquid hydrogen related hazards, regulation, codes and standards, utilization of hydrogen in various sectors, global status and future directions