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Energy Innovation and Integration for a Clean Environment

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The World is engaged in the challenge of a rapid de-carbonization of its economy to try to control global warming. The 6th Course of the Joint EPS-SIF Energy School has been held from 19 to 23 July 2021 to address how innovation in the energy sector and integration of different technologies can contribute to this goal. The COVID19 emergency has forced the event to be fully online. Nevertheless, the 55 students and the 20 speakers attending the school have enjoyed lively discussions.

The impact of anthropogenic CO2 is recognized to provide the main quantitative explanation of the increase in the energy flux in the atmosphere leading to global warming and the global thermodynamics of climate change is reasonably well understood, although how warming affects the weather is less well understood (H. Schmidt). As most of the world greenhouse emissions are produced by the energy sector, the goal of a clean environment has important consequences on energy production.

Following a well established format from the previous editions, the Course has addressed general aspects of the energy problem and the physical challenges of specific energy technologies. A focus on the impact of COVID19 has been maintained with a talk on “Pandemics and Global Health” (S. Vella) and two talks on air quality (H. Hahn) and energy perspective (M. Van den Broek) after corona.

The impact that the access to energy sources has on everyday life can be grasped by noting that the primary energy consumption of an average European is equivalent to the energy consumption of 50 human bodies. Thus, our energy use corresponds to the work made by 49 “slaves” for each of us. The consequence of the industrial and scientific revolutions has been many “slaves”, better health and longer life (C. Buchal).

The scale of the challenge can be measured by looking at the recently proposed *IEA Net zero emission by 2050* scenario . The scenario advocates for a substantial increase in renewable energy sources (covering 2/3 of the energy supply in 2050), in a doubling of the present nuclear power generation and in the reduction of fossil fuels from 80% in 2020 to 20% in 2050 with a massive use of carbon sequestration and storage.

As to renewable energy sources spectacular advances in the conversion efficiency of photovoltaic cells have been achieved over the last 40 years with values around 50% obtained with multi-junction plus concentration technologies (S. Siebentritt). Wind power production is increasing with data from large offshore installations becoming available over several years of operation (H.J. Wagner). However, both sources are intermittent and require substantial investments in electricity storage systems either based on hydrogen production via water splitting, storage and conversion (E. Pellicier) or batteries (M. Tromp).

The use of these technologies on the scale needed for a net zero emission scenario still presents challenges. In addition the transition from centralized to distributed electricity production has an impact on the grid stability and requires novel control algorithms for network management (J. Sherpen).

Nuclear energy is also a main player in the energy transition with a large number of new reactors being built in emerging economies (M. Ripani and S. Leray). On a longer term, fusion could provide a virtually unlimited, clean and safe energy source (J. Ongena and F. Romanelli).

The School has also addressed other crucial issues for energy sustainability such as the development of new materials for energy technologies (P. Rudolf), the exploitation of fossil fuels and the development of carbon capture and storage (J. Craig) and the use of biomasses (D. Thrän).

As noted by F. Wagner in his conclusions, de-carbonization requires a portfolio of options in which renewables will have to provide the lion share but other technologies such as nuclear and carbon capture and storage will be needed. Any debate on the energy policy requires a basic understanding of the whole energy field. This is the purpose of the School on

Energy. It is our collective responsibility as physicists to ensure that such a basic understanding permeates the political debate.

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