To complement these efforts, Germany will have to ensure that it remains attractive, and further improves its attractiveness, as an R&D location for foreign enterprises. Germany can position itself by providing a highly-developed R&D environment, e.g. by means of collaborations with German research organisations. How to excel in this regard has been demonstrated in Switzerland. Here, examples include the long-standing collaboration between the IBM research centre and the ETH Zurich, and the development of joint research centres by universities and foreign enterprises such as the SAP research centre in St Gallen. Intensive institutional collaboration between German research organisations and higher education institutions on the one hand, and foreign enterprises on the other hand, should be systematically targeted and fostered. This would lead to the launch of new domestic research centres and, as a result, to increased value added and employment in Germany.

As regards German research organisations that are publicly funded, intensified commitments abroad will only lead to the desired results if they succeed in benefitting both parties, i.e. Germany and the target country. Over the last decade, numerous initiatives have been launched. Here, it is essential to critically assess if the knowledge flows resulting from this are bidirectional and mutually enhance each other. This aspect will be further dealt with in Chapter B5, on the example of China.

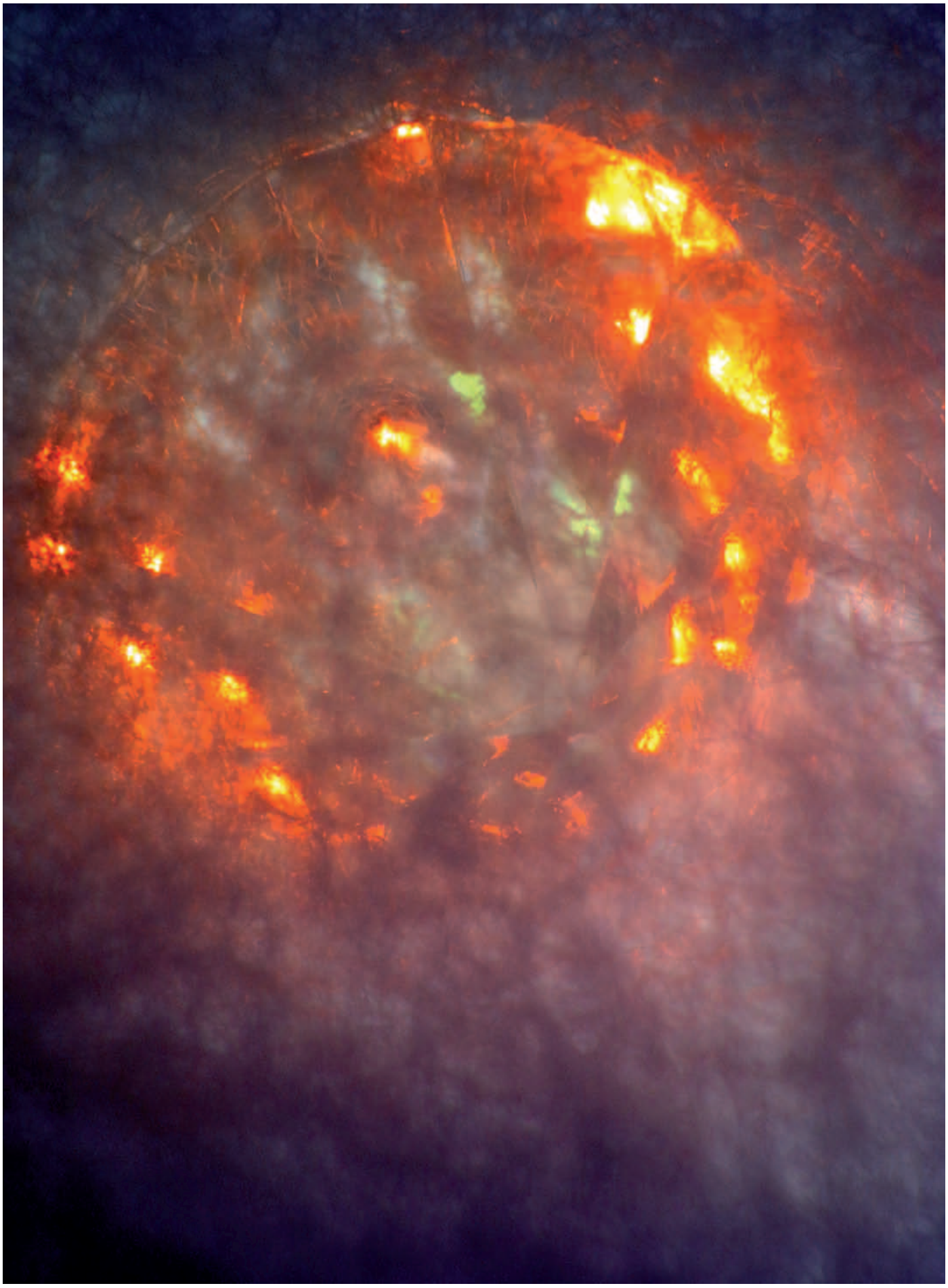
A 4 THE ENERGY TRANSITION AS AN INNOVATION OPPORTUNITY

The disasters at several nuclear power reactors in Fukushima in the spring of 2011 triggered a broad, intensive social and political debate about the future of energy supply in Germany. This was followed by a legislative package that was adopted by the German parliament on 30 June 2011. Among other things, it provides for a step-by-step decommissioning of all German nuclear power reactors by the year 2022.[42] To complement this nuclear phase-out, it is also planned to significantly reduce the use of fossil fuels as a means of climate protection. This "Energy Transition" *(Energiewende)* shall be facilitated not only by a considerable improvement in the production, transport and application of energy that is technically usable, but also by a significant increase in the use of renewable energy sources generated from e.g. the sun, wind, biomass, and geothermal sources. In implementing this energy shift, Germany aims to phase out nuclear energy, while at the same time achieving their self-defined objectives in terms of climate protection.[43]

The Expert Commission would like to comment on three dimensions of the Energy Transition: (1) responses from the German innovation system in the field of non-university research institutions,[44] (2) changes in the Federal Government's research and energy policy, and (3) the relevance of the Energy Transition for innovations in Germany as an industrial location. The Expert Commission is aware of the fact that substantial strategic adjustments in the area of research and innovation require a sufficiently long preliminary phase. Hence, the current status should be considered as no more than a provisional snapshot.

The Fraunhofer-Gesellschaft (FhG) has dealt with nuclear energy and fossil energy conversion only to a limited extent in the past.[45] Their focal points in the field of energy have been, and still are, renewable energy (solar, wind, biomass), energy efficiency technologies, energy-efficient buildings and building components, intelligent electricity networks, as well as energy storage and electromobility. The Fraunhofer-Gesellschaft also comprises an Energy Alliance, a co-operation in which 15 out of the 60 existing Fraunhofer institutes participate.[46] The Fraunhofer-Gesellschaft does not see the necessity to make major adjustments to their R&D focal areas as a result of the Federal Government's energy shift. The reason for this is that the FhG portfolio planning is already directed at further expanding and complementing its strengths in the key fields mentioned above.

The Helmholtz Association (HGF) focuses its activities on renewable energy, efficient energy conversion, nuclear fusion, as well as the "technology, innovation, society". As a response to the new energy legislation, several new strategic "Helmholtz Energy Activities" *(Helmholtz Energieaktivitäten)* have been launched within the HGF,[47] and some of these promise to take effect in the near future. For the 2015-2019 funding period, HGF is also planning to further advance its efforts in the area of renewable



1/10 Transilluminated fibrous tissue

2/10 Liquid at rest

energy and efficiency technologies. This will be complemented by enhanced efforts in the fields of energy storage technologies, grid issues and system solutions. In the current funding period (2010-2014), 42 percent (EUR 562 million) of the Helmholtz Association's basic funding resources allocated to energy-related research will be granted to activities in the field of nuclear fusion.[48]

For many years now, the Max Planck Society (MPG) has been attaching special attention to sustainable energy supply as a strategically important field of work.[49] Since the MPG's scope of implementation usually extends to a decade or more, Germany's accelerated phase-out of nuclear energy does not affect MPG's long-term objectives. MPG's research activities in the field of future energy supply are focussed on nuclear fusion (in close co-operation with HGF[50]) and chemical energy conversion. As regards chemical energy conversion, the Max Planck Society is currently launching an MPG institute for basic research in (bio-) chemical energy research.

The research facilities of the Leibniz Association (WGL) are primarily engaged in energy-related research into materials and technologies.[51] In addition to that, economic, societal, ecological and environmental issues are being analysed with regard to current and future power supply systems. In order to further consolidate these research activities, WGL has initialised first steps towards the launch of a research association on energy issues.

The Expert Commission welcomes these diverse activities that contribute to the Energy Transition through scientific and technological advancements. Yet, it seems that a comprehensive/all-encompassing co-ordination of all of these non-university research institutions currently exists only in rudimentary form. Moreover, the Expert Commission sees the need for additional debates and adjustments. In view of the Energy Transition, the Expert Commission also recommends reconsidering the nuclear fusion.[52] In particular, it seems questionable whether Germany should maintain to simultaneously pursue two different technological concepts, i.e. Tokamak and Stellarator. The Expert Commission further suggests reassessing the relevance of nuclear transmutation research[53] for Germany.

On 3 August 2011, the Federal Government adopted their 6th Energy Research Programme for Germany *(6. Energieforschungsprogramm für Deutschland)*.[54] This programme already responds to the government's nuclear phase-out policy that was adopted in June 2011. The 6th Energy Research Programme is the result of an extensive consultation process: although drawn up under the aegis of the Federal Ministry of Economics and Technology (BMWi), the programme is in fact the product of a close collaboration between the BMWi, the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Ministry of Education and Research (BMBF). All measures suggested in the Energy Research Programme are part of the Federal Government's dedicated Hightech Strategy. While the Expert Commission welcomes the Ministries' increasingly collaborative approach to energy-related R&D policies, it is calling for further steps towards an effective co-ordination of energy research activities. Moreover, it does not suffice to merely co-ordinate publicly funded research – the economic players have to be integrated through a pre-competitive co-ordination process.[55]

In the context of the 6th Energy Research Programme, the following cumulative sub-budgets are earmarked for the years 2011 to 2014: EUR 1.2 billion for efficient energy conversion and usage as well as energy efficiency; EUR 1.4 billion for renewable energy; EUR 0.3 billion for nuclear safety and disposal; and EUR 0.6 billion for nuclear fusion. The funding volume of the efficient energy conversion and renewable energy budget shall be increased by approximately 40 percent between 2012 and 2013. Given the objectives of the Energy Transition, these budgetary developments appear to be coherent.

The Expert Commission understands that the resources designated for nuclear safety and disposal according to the 6th Energy Research Programme will be used for research and development purposes only. In the view of the Expert Commission, any resources that are made available to nuclear fission and nuclear fusion technologies in the context of the Euratom agreement should be reported in conjunction with the Energy Research Programme, a measure that would further enhance transparency. Considering the strained national budgets in Europe, the Expert Commission would like to reiterate its

earlier critical comments on the management of the nuclear fusion programme ITER.[56]

The Expert Commission expressly welcomes the fact that the Energy Research Programme, in addition to sustainable power supply, strongly addresses issues regarding efficient energy usage, energy supply for buildings, and sustainable transport technologies. It is striking, however, to see that the report on the 6th Energy Research Programme only briefly describes and discusses the research areas of "Nuclear safety and disposal research and radiation research" as well as "Fusion research".[57] Such scarce documentation appears to be disproportionate in comparison to the resources that are channelled into these areas.

From among the leading economies worldwide, Germany assumes a leading role in transforming energy systems towards sustainability. The Energy Transition offers Germany the chance to position itself as a high-tech location on the global market e.g. in the following fields: (1) technologies for efficient energy use, (2) use of renewable energy sources, (3) energy-efficient building technologies, (4) energy storage technologies, (5) efficient and intelligent power networks, and (6) sustainable transport technologies. With its excellent R&I infrastructure, Germany has very good prospects of maintaining, extending or acquiring a global leading role in most areas of sustainable energy supply technologies – as a system provider, manufacturing equipment supplier and service provider. In order to transform this potential into real innovation leadership, a concerted commitment of all stakeholders is now required. Moreover, energy, environmental and innovation policies will have to be co-ordinated to a much higher degree than has been the case in the past. This will prevent welfare losses in the context of the nuclear phase-out and let the positive impact of the Energy Transition come into full effect.