Appendix 1 – Examining Biodiversity Impacts of Key Renewable Technologies

The following sections review in further detail the impact of key renewable energy technologies and the range of impacts and issues associated with biodiversity; the following focuses on hydro power, bioenergy in its many guises, on and offshore wind and ground mounted solar.

The only renewable technology considered here that will nearly always have significant biodiversity impacts in the EU is the generation of ***hydroelectric power*** through schemes that include large impounded reservoirs. These impacts primarily result from habitat loss but also potentially profound changes to the hydrology and geomorphology of rivers below hydro-power dams. Loss of important habitats from reservoir creation can, in principle, be avoided by sensitive location, and downstream impacts can be mitigated by maintaining appropriate river flows. However, the need to place hydro reservoirs in mountain/upland areas means that habitats of high biodiversity value will almost inevitably be lost.

Small-scale/micro in-river hydro-schemes (i.e. that do not create large reservoirs) has the potential to limit negative biodiversity impacts provided: that sensitive sites are avoided – in particular unmodified high nature value river systems; other mitigation measures are taken and are effective; and that cumulative impacts of multiple schemes in the same catchment are fully taken into account as, for example, individually small impacts on fish passage can mount up. It should be noted that where existing modifications to river systems are already in place some in-river schemes may create opportunities for some biodiversity benefits by, for example, making use of an existing weir and adding fish-passes where they are not already present or adequate. Thus micro-hydro-schemes with effective fish passes can open up areas of river that had been cut off to migratory fish (some of which are highly threatened in Europe).

Bioenergy, i.e. the use of biomass to deliver energy via heat, power or through transport fuels, can have a wide variety impacts on biodiversity, some of which are highly significant. Unlike other renewable energy technologies, bioenergy, like fossil fuels, relies on a raw material that is 'used' within the energy process; while biomass is potentially renewable, as biomass can be regrown, the potential for this is finite, and dependent on the use of land, water and nutrients for ongoing production.

There are different classes of feedstocks, and different end uses to which these can be put. Bioenergy can be delivered from primary materials[1] or through the use of waste and residues from forestry or agricultural production. For all feedstocks streams, however, there are parameters that need to be respected in order to deliver environmentally appropriate deployment. These include, for example, the scale of use and environmental consequences of use that must be mitigated before biomass can be used in an environmentally neutral, or positive, way. The main environmental consequences, both in terms of biodiversity and potential carbon emissions, are associated with the production of the feedstock, ie how the biomass is produced and sourced. This is influenced by a number of key factors including: whether feedstocks are wastes, residues or from primary production; the type and extent of land used for production; and the nature of any change in resource use leading to potential displacement of existing uses of a given material and/or displacement of existing land uses.

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[1] In the form of conventional crops that deliver sugar, starch or oils (primarily for biofuels and bioliquids), energy crops (crops grown as main crops primarily for energy purposes on agricultural land including short rotation coppice) and woody biomass from forestry.

Bioenergy represents the biggest anticipated contributor to the delivery of the renewable energy targets up to 2020, with use predicted to continue to expand up to 2030. Between 2000 and 2012, the use of biomass for energy effectively doubled reaching 102 Mtoe in 2012: 75 Mtoe in bioheat; 12 Mtoe in bioelectricity; and 15 Mtoe in biofuels for transport[2]. Based on Member States' planned commitments within the NREAPs, submitted to demonstrate their approach to complying with the RED's targets, by 2020 139 Mtoe of bioenergy is anticipated[3].

The key challenge for bioenergy, indeed for all biomass production, is that the environmental impacts are sensitive to the volume of supply at both the local and global level. Estimates of land use for the bioenergy levels suggest 44.5 Mha of land and forest area were in use in 2010 to deliver bioenergy within the EU. This would rise to an estimated 57 Mha by 2020 were anticipated use patterns to be delivered. This would encompass approximately 14 Mha of cropland (equivalent to approximately 12 per cent of the total EU area) and 43 Mha of forest land[4].

The order of magnitude change in biomass use for energy has implications associated with land use change and the increased intensity of land use, within the EU and globally. As a consequence there are significant potential biodiversity impacts. Land use change can be direct or indirect ie converted directly for use by the feedstock[5] or converted indirectly as a consequence of the displacement of other crops from land now used for bioenergy feedstocks. Critically, this may result in conversion of semi-natural or natural ecosystems to agricultural or forestry production with the loss of associated habitats and species. There are also potential, ongoing land management changes ie increasing intensity of use of cropland or increasingly intensive exploitation of forest systems including those currently unmanaged and those in management. Modelling of increased biomass for heat and power particularly shows an emphasis on increasing intensity of forest management moving forward, the nature of such management choices is important in determining biodiversity and wider outcomes.

Land use change and increasing land use management intensity also impact on the carbon emissions associated with the biomass feedstock's production, in some cases significantly reducing or completely offsetting emission saving[6]. These impacts, however, vary depending on the type of feedstock used based on: the management conditions applied during feedstock cultivation; the scale of land use change associated with production; the existing land use being replaced; whether biomass is explicitly produced for energy or represents a byproduct and/or waste from another activity; and the alternative potential uses of the biomass. Moreover, in particular the GHG balance of bioenergy use also depends on the end use to which it is put ie use for heat and electricity may replace coal and gas use, use as a transport fuel will impact on fossil oil.

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[2] Aebiom, 2014, European Bioenergy Outlook 2014

[3] Beurskens and Hekkenberg (2011) Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, Energy Research Centre of the Netherlands and the European Environment Agency

[4] Schutter & Giljum (2014) A calculation of the EU Bioenergy land footprint, Institute for the Environment and Regional Development and Vienna University of Economics and Business (WU)

[5] It should be noted that under the RED direct conversion of land with high biodiversity value or high carbon stocks is prohibited for biofuels and bioliquids used for energy purposes as part of sustainability criteria relating to these products.

[6] Bowyer, C (2010) Anticipated Indirect Land Use Change Associated with Expanded Use of Biofuels and Bioliquids in the EU – An Analysis of the National Renewable Energy Action Plans, IEEP, London

There is clear evidence that onshore and offshore **wind** turbines can kill birds and bats and result in disturbance/ displacement, barrier effects (which may, for example, interrupt movements between feeding areas) and onshore habitat degradation (such as from the hydrological effects of access roads and their drains or the drainage of peatlands for wind farm construction). Impacts on most habitats and species, however, are typically very low, unless the turbines are placed where particularly vulnerable species occur (such as large raptors, seabirds and waterfowl) or where vulnerable species congregate in large numbers (eg near key feeding area or along migratory flyways and bottlenecks). Impacts can therefore normally be minimised by careful site selection. In the marine environment, its seems likely that some sensitive benthic habitats and associated species will benefit considerably from the exclusion of trawling in the vicinity of windfarms; but long-term studies of this have yet to be carried out. However, broader siting concerns associated wind turbines remain ie in the context of birds in particular.

There is little information available on the biodiversity impacts of **solar** panels in large-scale, ground mounted solar farms. Any impacts that do arise are likely to be associated with habitat modification or loss as a result of their footprint, shading effect and management of surrounding vegetation. Positive biodiversity impacts may, therefore, arise if they replace intensively cultivated farmland with extensively managed grassland between well-spaced panels. Guidance published on locating solar farms[7] highlights the preferred use of lower agricultural land grades for ground mounted solar (grades 3b, 4 and 5 in the UK) these primarily encompass lower yielding agricultural land that is often grassland, permanent pasture or rough grazing. This would imply potential impacts on semi-natural or species rich grasslands, and would therefore more often have detrimental impacts.

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[7] For example guidance by BRE for the UK Planning guidance for the development of large scale ground mounted solar PV systems - https://www.bre.co.uk/filelibrary/pdf/other_pdfs/KN5524_Planning_Guidance_reduced.pdf

Case Example – Small Scale Hydro – the importance of cumulative assessment and appropriate enforcement

Even though hydropower generation itself produces no greenhouse gas (GHG) emissions the construction of dams and reservoirs are associated with a wide range of GHG emissions. Moreover, **large-scale hydropower plants have a significant impact on ecosystems and biodiversity**; they affect water availability downstream and disturb habitats, which are flooded above the impoundments. In contrast, **small-scale hydropower**, which refers to hydroelectric power plants below 10MW installed capacity, **is considered to be more environmentally-friendly** as it does not interfere significantly with river flows and thus ecosystems are not substantially altered[8].

Nevertheless, the more widespread use of small-scale hydropower in recent years has led to the questioning of the environmental-friendliness of such installations and publications have started to show a **mixed picture of environmental impacts**. For instance, in the UK small-scale hydropower systems (SHS) are usually sited on existing barriers such as weirs or waterfalls, which are already a barrier for fish passage. The siting of a SHS with fish passes therefore can result in improved fish passage. Nonetheless, poorly-designed systems can pose a detrimental impact on fish populations and river ecosystems. One of the main concerns is associated with the loss of connectivity for diadromus and other migratory species. Furthermore, low water levels during dry periods can also affect ecosystems. A potential solution to prevent such impacts could be the setting of minimum acceptable flows[9].

The **cumulative impacts** of SHS are also a major concern. Larnier (2008)[10] analysed the different types of fish passes used in France, where more than 1,700 SHS are in place. He concluded that even though the technology of some fish passes can be considered to be well-developed, more rigorous monitoring and evaluation is needed of the effectiveness of the different upstream and downstream passes. Moreover, the analysis showed that as the fish passes cause delays in fish migration, the successive hydropower installations lead to a significant cumulative impact. According to Abbasi and Abbasi (2011)[11], the extensive use of SHS along one river is likely to cause, per kilowatt of electricity generated, the same or even greater cumulative environmental impacts than large-scale hydropower plants.

Experience in Romania showed that despite the **Natura 2000 status** of the Sambata, Sebes, and Dejani-Lupsa rivers, more than 50 SHS were constructed in the area. WWF (2013) revealed that there were no proper public consultations and **Environmental Impact Assessments** (EIA) were not undertaken. The installation of the SHS was also considered (by the report authors) in breach of the Water Framework Directive as the constructions negatively affected the water's ecological status. In recent years, there has also been a boom of SHS built in Bulgaria. Many of the hydropower systems are built within national parks and protected areas. Furthermore, the plants are usually built without an overall energy plan and are **not properly licensed or monitored**[12].

Experience shows that **even though small-scale hydropower systems have the potential to be more environmental-friendly** than large-scale hydropower plants, **close attention should be paid to the proper design of the systems, impact assessments - with a special focus on the cumulative impacts, and monitoring exercises**. Moreover, siting should focus on improvements to previously modified river systems rather than allowing amendment to remaining free-flowing river systems[13].

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[8] IEA (2008) Energy Technology Perspectives, Scenarios and Strategies to 2050

[9] BIO, IEEP and CEH (2014) Towards integration of low carbon energy and biodiversity policies, An assessment of impacts of low carbon energy scenarios on biodiversity in the UK and abroad and an assessment of a framework for determining ILUC impacts based on UK bio-energy demand scenarios, A report for DEFRA

[10] Larinier, M. (2008) *Fish passage experience at small-scale hydro-electric power plants in France*. Hydrobiologia No 609, (1) pp97-108

[11] Abbasi, T. and Abbasi, S.A. *Small hydro and the environmental implications of its extensive utilization*, Renewable and Sustainable Energy Reviews, Volume 15, Issue 4, May 2011, Pages 2134-2143, ISSN 1364-0321

[12] Cooke, K. (2014) Bulgaria's micro-hydro power surge, Climate News Network, Available at: http://www.climatenewsnetwork.net/bulgarias-micro-hydro-power-surge/

[13] WWF (2013) Seven sins of dam building

The Main Impacts of the Use of Renewable Energy in the EU on Biodiversity

Energy technology	Main areas impacted	Direct mortality	Habitat loss and degradation	Other negative impacts	Key mitigation measures	Positive impacts	Climate Mitigation Risks	Overall residual impacts
Onshore wind	Widely in the EU, especially in coastal and upland areas	Some birds and bats are vulnerable to turbine collision, but mortality rates are normally too low to have population level impacts on most species. But inappropriately sited turbines can have substantial impacts, especially on small populations of slow-breeding, long-lived species.	Direct losses from turbines are very small, but associated service roads and other infrastructure can degrade habitats, such as hydrological impacts on peatlands.	Some bird species can be displaced from areas surrounding wind farms and they may act as barriers, which can for example interrupt feeding and roosting movements.	Appropriate siting is crucial to avoid sensitive habitats and significant collision impacts. Turbine layout and design can also reduce impacts. Habitat impacts can be minimised by sensitive construction and subsequent habitat restoration.	No significant biodiversity benefits are likely.	Appropriate siting important, potential emissions from soils if sited on high carbon stock land or if site development requires drainage of peat land.	Impacts are generally low, if turbines are sited in appropriate locations.
Offshore wind	Mainly in shallow sea areas of NW Europe	Normally low for most dispersed seabirds and migratory species, but inappropriately placed large-scale wind farms may have high impacts on localised seabirds and some migrants.	Direct losses are small, but construction activities and installation of subsurface transmission cables can disrupt local ecosystems, e.g. from higher turbidity.	Pile driving during construction can disturb marine mammals, but impacts will probably be temporary.	Appropriate siting is crucial to avoid sensitive habitats and significant collision impacts. Turbine layout and design can also reduce impacts. Habitat impacts can be minimised by sensitive construction methods and timing	The exclusion of trawling in the vicinity of windfarms protects the seabed and therefore benthic habitats and associated species. Turbine bases also create artificial reefs, which may increase habitat diversity and support associated fish and invertebrates.	N/A	Impacts are generally low, if turbines are suited in appropriate locations. And significant positive benefits can occur for some marine habitats and associated species.
Hydro-electric – large-scale impoundments	Mountainous areas, particularly in NW Europe	Small number of fish killed in poorly designed schemes.	Large losses, often affecting ecologically valuable habitats.	Dams prevent upstream movements of migratory fish and lead to major changes in river flow downstream, which disrupts habitats.	Avoidance of habitats of high biodiversity value is critical. Minimum flow rates to maintain important downstream habitats and species.	Expansion of open water habitats above impoundments, but this mostly benefits common species.	N/A	Usually highly detrimental.

Energy technology	Main areas impacted	Direct mortality	Habitat loss and degradation	Other negative impacts	Key mitigation measures	Positive impacts	Climate Mitigation Risks	Overall residual impacts
Hydro-electric – small-scale run-of river	Mainly upland areas, but also on some lowland rivers.	Low downstream flows and sudden changes in flows may kill fish and other species.	Small losses from small-scale run-of river schemes.	Small-scale hydro schemes can restrict movement of migratory species and result in reductions in river flows.	Very sensitive sites can be avoided and well-designed fish passes can reduce impacts. Minimum flow rates to maintain target habitats and species.	Potential to improve fish passage through modification of existing weirs and barriers with effective fish passes.	N/A	Variable: largely depending on whether the scheme results in new impoundments and/or fish passes.
Ground mounted solar	Becoming widespread, although most are in lowlands in S & C Europe.	Some mortality from insects mistaking the panels for water.	Potential loss of biodiversity rich semi-natural habitats, depending the density of solar panels and the type of habitat that is being replaced.	N/A? Water use for maintenance in desert areas (outside Europe)?	Avoidance of important sites / habitats is of prime importance. Other measures include avoiding soil sealing, minimizing the canopy effect, and ensuring low intensity management of vegetation.	Can replace some habitats of low ecological value (eg arable) with habitats of higher biodiversity value if appropriately managed. Cessation of ploughing and the use of fertiliser and pesticides may reduce soil erosion and water pollution.	N/A	Variable: largely depending on the habitat that is replaced, its on-going management and density of panels. Benefits are at most modest, but detrimental impacts can be very high.
Biofuel from conventional crops	Widely in the EU, as arable crops, but also substantial impacts from imports, especially in N and S America.	As for arable agriculture - possible impacts on birds or small mammals during harvest, impacts from cultivation on soil biodiversity.	No new direct impacts if grown on arable land, but can lead to direct and indirect loss of semi-natural habitat and, particularly outside the EU, natural habitats of very high biodiversity value	May lead to intensification of land management and crop management.	Avoidance of high-biodiversity habitats, but ILUC difficult to regulate. Good agricultural management practices.	Normally none.	Avoidance of high carbon stock land, but ILUC is difficult to regulate and need to be taken into account.	Variable: can be low in existing arable areas of the EU but very high international impacts.
Biomass from primary wood production	Widely in EU intensification of woodland management .	Some incidental loss during harvesting.	Clear-felling and /or conversion to intensively managed forest or plantations of fast growing (often non-native) species with short rotation periods.	Disturbance from increased forestry operations.	Avoidance of high-biodiversity habitats, but ILUC difficult to regulate. Sustainable Forest Management practices.	Some potential for expansion of woodland on land of low biodiversity value. Selective thinning and restricted clear-felling of undermanaged woodland may improve habitat condition.	Changes in management and increased intensification of extraction can lead to changes in soil carbon emissions and biomass left in situ. Biomass inherently produces carbon emissions from combustion and this is over a different time horizon to regrowth of biomass especially for species with longer harvesting cycles.	Variable: with small-scale use in appropriate locations beneficial, but large-scale clear felling of semi-natural / old forest being highly damaging.

Energy technology	Main areas impacted	Direct mortality	Habitat loss and degradation	Other negative impacts	Key mitigation measures	Positive impacts	Climate Mitigation Risks	Overall residual impacts
Biomass65 from agricultural and forestry residues	Widely in the EU – changes of agricultural and forestry management.	As for arable and forestry systems: some losses during harvesting.	Over-extraction of straw may impact soil fauna. Intensive extraction of coarse woody debris from forests would result in the loss of habitat for deadwood specialists and have knock-on impacts. Stump removal causes soil disturbance.	Disturbance from increased forestry operations.	Limitations on the amount of residues extracted. Sustainable Forest Management practices.	Could help support selective thinning and restricted clear-felling of existing undermanaged woodland which may improve habitat condition.	Changes in management and increased intensification of extraction can lead to changes in soil carbon emissions, increased inputs and less biomass left in situ. Potential for forestry residues, in particular, to have a lag between emission production and regrowth due to length of harvesting cycle.	Generally very low, if limited to app-appropriate levels.
Energy crops	Across the EU but with potential global impacts in terms of ILUC.	Some incidental loss during harvesting.	Potential targeting land of low agricultural quality, but high biodiversity value, such as semi-natural grassland.	Potential for displacement impacts if not placed on under used land/high quality arable land	Avoidance of high-biodiversity habitats, but ILUC difficult to regulate.	Benefits for scrub / tall grass associated species. Can benefit downstream aquatic habitats from reduced fertiliser use and soil erosion if replacing intensive arable crops.	Avoidance of high carbon stock areas and direct land use change. Potential benefits associated with shift from annual to perennial cropping but this will depend on location, soil type and management regime. Potential ILUC impacts and increasing in intensity of management across wider cropland.	Variable: with small-scale use in appropriate locations (eg on arable land) beneficial, but large-scale production and/or conversion of semi-natural habitats highly damaging.

A full list of all the references on which this table is based can be provided upon request from cbowyer@ieep.eu

Appendix 2 – Summary of Key EU Environmental Legislation Important in enabling Environmentally Positive Renewable Energy

EU Legislative Measure	Full Reference	Objective	Key Details
Environmental Impacts Assessment (EIA) Directive	2011/92/EU	To ensure that projects that are likely to have significant effects on the environment are subject to an environmental assessment prior to their authorisation.	The two Directives are to a large extent complementary: the SEA being "up-stream" so that it can identify the best options to deal with potential impacts at an early planning stage, and the EIA being "down-stream" so that it can deal with project-specific impacts at a later stage. Assessments provide environmental reports that should identify and assess significant environmental effects, mitigation measures and alternatives, and consult with relevant authorities and the general public in the process.
Strategic Environmental Assessment (SEA) Directive	2001/42/EC	To ensure that the environmental consequences of certain plans and programmes are identified, assessed and taken into account during their preparation and before their adoption by the competent authorities.	
Birds Directive	2009/147/EC	*Member States shall take the requisite measures to maintain the population of the species referred to in Article 1 at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level.*	The Directives have two primary approaches to achieving their objectives – firstly, measures for the protection of species wherever they occur, and secondly the protection of sites of particular importance for species and habitats of Community Interest. The latter, designated under the two Directives, are intended to form 'a coherent ecological network' referred to as the Natura 2000 network.

Habitats Directive	92/43/EEC	*To maintain or restore, at favourable conservation status (FCS), natural habitats and species of wild fauna and flora of Community interest*.' FCS can be described as "*a situation where a habitat type or species is prospering (in both quality and extent/population) and with good prospects to do so in the future as well"*.	Plans or projects which, individually or in combination with others, are likely to have a significant effect on any Natura 2000 site, but are not directly connected to their management (for nature conservation), require an 'Appropriate Assessment' of the implications of the plan or project in view of the site's conservation objectives, and require the precautionary principle and mitigation hierarchy to be followed. Competent authorities can only agree to the plan or project after having ascertained that it will not adversely affect the integrity of the site concerned. Projects or plans that may have adverse impacts can be allowed go ahead if they are of overriding public interest and there are no alternative solutions, in which case compensatory measures (such the habitat restoration) must be undertaken. However, for Natura 2000 sites that host a priority habitat type or species the only overriding public interest considerations that may be raised are those relating to human health and public safety. Therefore, there should be no circumstances in which a renewable energy project that would have significant residual impacts on such a Natura 2000 site should be allowed to go ahead, irrespective of the potential for compensation measures.
Water Framework Directive (WFD)	2000/60/EC	To achieve good ecological status of surface waters, based on detailed ecosystem criteria (including the presence of characteristic species).	Provides a firm legal foundation for the integration of biodiversity objectives into a number of land (and water) use decisions. The WFD requires all pressures preventing the achievement of its ecological objectives to be assessed and measures put in place to address these pressures, such as through land-use change, pollution control and reducing abstraction. The WFD's requirements only directly address the condition of the water body itself and not bankside or other habitats. The Directive's influence on the renewable energy technologies covered in this report is limited to hydro-power projects. It has the powers to ensure that hydro-power schemes do not result in the degradation of the water body, for example through pollution (during constriction), low or erratic flows and the creation of barriers to fish migration.