DELIVERABLE 8.4

Policy recommendations and implications

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1 Contents

LIST OF FIGURES

LIST OF TABLES

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PUBLISHABLE SUMMARY

ZeroWINs Work Package on policy implications and recommendations aims to provide targeted policy recommendations based on the ten ZeroWIN industrial cases which support the development of industrial networks in practice. Work includes policy analysis, stakeholder consultation and a synthesis of the results from the ZeroWIN industrial cases. From an environmental perspective all the case studies suggest that industries can reduce greenhouse gas emissions by at least 30 per cent and can achieve a 70 per cent overall reuse and recycling rate for waste through successfully engaging in an industrial network. However, consultation with industry stakeholders has revealed a prevailing scepticism regarding industrial networking and its underlying principle of mutual benefit through the exchange of waste materials. Discussions with the ZeroWIN case studies as well as feedback from the stakeholder consultations have shown that there are a couple of key constitutive factors determining the applicability and implementation of industrial networks. These comprise: economic benefits, material quality and standardization, access to information and material, by-product recognition and the facilitation of industrial networks.

Further, the ZeroWIN construction and demolition case studies consider the low embracement of pre-demolition audits or waste management plans to be a substantial barrier for resource efficiency. Policy recommendations thus target public demolition and construction projects and implementing legislation (on a national level) that requires all public construction and demolition projects to undertake a pre-demolition audit, respectively waste management plan prior to planning permission being granted. It is important to note though, that, as practice in e.g. the UK has shown, these measures could only if there is

sufficient funding steered towards monitoring and policing. For public buildings in particular, the tender process, prescribed by legislation, results in a lengthy delay between the design and construction phases. Thus, the builder is normally not involved in the design phase and has little ability to change the materials, equipment and techniques set by the architects in the design stage. On a policy level, one of the key recommendations made is to include the specification of sustainable or secondary material in public procurement tenders, potentially also to award more "design-and-built" contracts in public procurement. Further, the cases recommend that policy should work with building certification/ accreditation schemes (which are voluntary schemes as of now) as to schemes should provide credits for the use of sustainable or secondary materials and induce industrial networking in their crediting system. The public authorities are the biggest awarding authority in the construction and demolition sector. Public authorities are seen as a major potential driver in introducing recycled materials to the market and by this also building confidence into the quality (via green public procurement).

The ZeroWIN case studies researching electronics - or more specifically Information Technologies (IT) - reuse have stressed that a major barrier towards the functioning of the industrial network is caused by supply uncertainties in terms of quality, timing, and quantity of returned products. The constraint of quality assurance can be addressed by the aforementioned standard for second-hand components, so that the reliability of parts and components can be ensured. Separate reuse and recycling targets in the WEEE Directive for B2B and B2C would further increase the availability of returned products and thus parts and components for reuse. Knowing what quantities of products and materials are available and also in what location they are available is important for the success of the proposed D4R industrial network. ZeroWIN has researched Radio Frequency Identification (RFID) used in conjunction with the appropriate architectural frameworks to address this issue through increasing the visibility of material in industrial networks. Business-to-business (B2B) waste electrical and electronic equipment poses a huge potential for reuse, and correspondingly towards an improved resource efficiency. However, the majority of B2B WEEE flows into independent networks of collectors for treatment and value recovery which are not accounted for in the WEEE Directive. Against this background the case recommends that the collection rates of the largest collecting organisations should officially confirmed on an annual basis, while acknowledging the commercial sensitivity of this sector.

One of the key measures under the photovoltaics case study to achieve the ZeroWIN environmental targets comprises the use of off-specification and second-life PV modules. A legislative tool to counter industry reservation is to set a minimum reuse target for end-of-life PV systems in the WEEE Directive. This needs to be supported by guarantee schemes on quality and performance to essentially engage PV systems integrators or operators in the use of off-specifications and second-hand hand modules. CS2 members further propose to promote industry clustering and common energy and water servicing (by sharing mini-grids of energy and water between neighbouring plants) and the corresponding facilitation of the administrative permitting. Further, Energy Service

Companies could play a key role, as to incorporate the concept of industrial symbiosis, and the addition of water mini-grids in their work.

On a more general level, ZeroWIN's case study on the use of a plastics recyclate in the automotive industry suggests steering European Union funding towards more research in reuse and recycling technologies, the substitution of materials as well as the development of guidance on best available technologies (BAT). By this case study, all technical preconditions (product development and recycling process, material specifications for recycling of glass-fibre enforced plastics) are made available. The technical barriers regarding the development of the control housing were solved within the case study. Supporting more research projects like ZeroWIN would enable the development of technical solutions, while at the same time proving the economic business case to trigger industry interest and trust in industrial networks.

1. INTRODUCTION TO THIS REPORT

ZeroWIN (Towards Zero Waste in Industrial Networks) is a five-year project running from 2009 to 2014 under the European Commission's 7th Research Framework Programme with 30 partners from 11 countries. The ZeroWIN project has developed effective strategies for waste prevention through industrial networks. Ten industrial case studies in the automotive, construction, electronics and photovoltaic industries (see Figure 1) form the core of the project and exchange energy, water and materials in such a way that waste from one industry becomes raw material for another.

The main aim of the ZeroWIN case studies is to show that the approach adopted by the ZeroWIN consortium can enable industrial networks in targeted sectors to meet at least two of the following targets:

- 30% reduction of greenhouse gas emissions,
- 70% overall re-use and recycling of waste,
- 75% reduction of fresh water use.

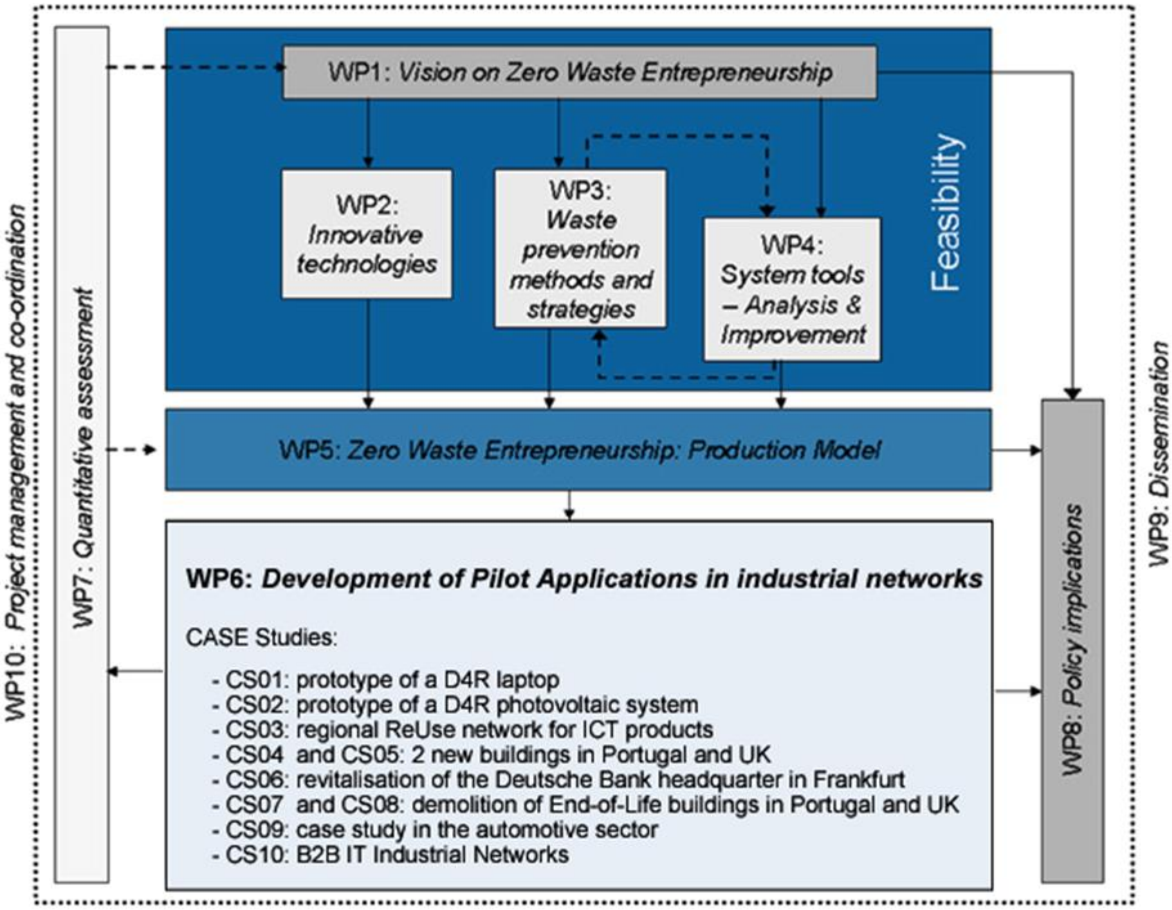

Figure 1: The ZeroWIN project and work packages

In addition, the ZeroWIN project aims to provide targeted policy recommendations supporting the development of industrial networks in practice. ZeroWIN's Work Package on

Policy Implications and Recommendations (WP8) investigates barriers, trade-offs, and overlaps of relevant legislation while integrating the outcomes of the above case studies at a policy level. Herewith, the following approach was taken:

In a first step, a selection of relevant European policies were reviewed according to their relevance for

(i) the ZeroWIN sectors construction, high-tech and automotive and
(ii) the ZeroWIN strategies which were identified to support industrial networking: supply chain management, ecodesign, industrial symbiosis, product stewardships

Then, in a second step, stakeholder interviews were carried out to get a more subjective feedback on the above analysis and add insights on industrial networks in practice.

In a third step, input from the ten ZeroWIN industrial cases was gathered, reflecting their feedback on barriers and enablers to industrial networks for their cases.

Based on the above three steps, draft policy recommendations were developed which were then presented and discussed at a stakeholder workshop to come to the final recommendations.

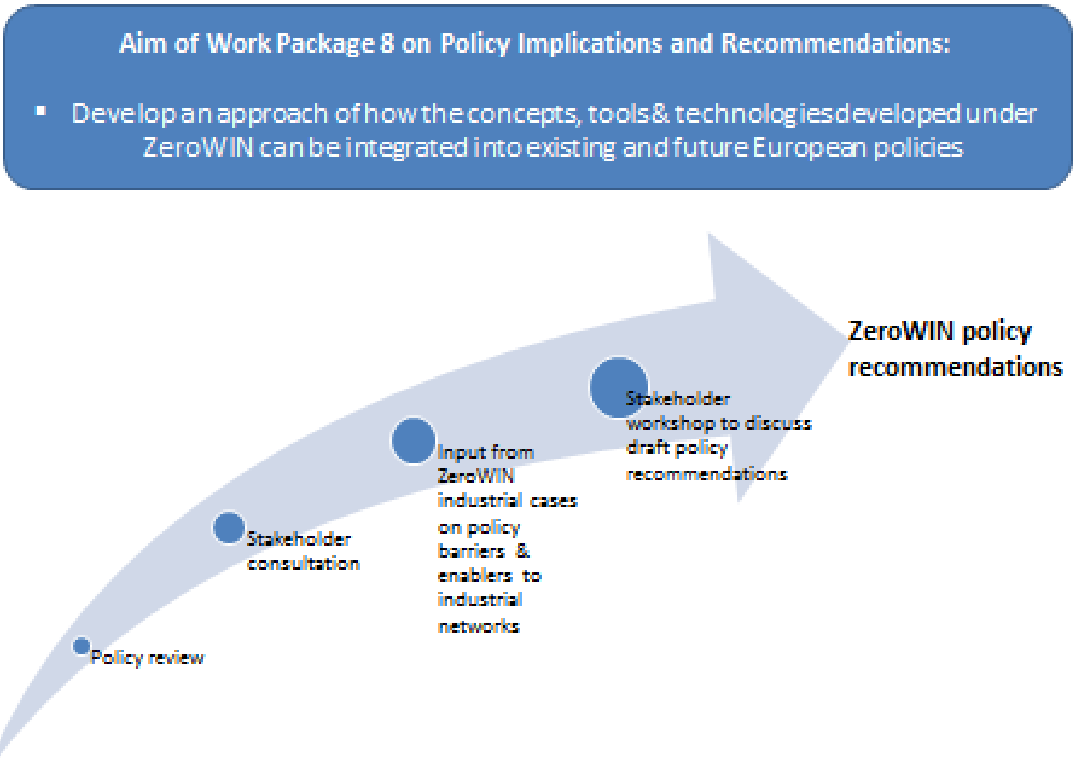

Figure 2: Overall approach Work Package 8 on Policy Recommendations

This document now presents the final recommendations based on this work. The results of the policy review and the stakeholder consultation are accessible in ZeroWIN Deliverable

8.1 and 8.2 respectively and available via the ZeroWIN project website[1]. A more detailed summary of the input from the ZeroWIN industrial cases on barriers and recommendations is included in Annex 1. An impact assessment of those policy options which were prioritized at the stakeholder workshop is presented in Annex 2.

2. RECOMMENDATIONS FROM THE ZEROWIN PROJECT

Achieving zero waste in industrial networks fits with the current flagship initiative for a resource-efficient Europe under the Europe 2020 strategy, the EU's growth strategy for a smart, inclusive and sustainable economy. The EU's Roadmap to a Resource Efficient Europe suggests that a resource efficient economy is one that "respects resource constraints and planetary boundaries, thus contributing to global economic transformation". It is "competitive, inclusive and provides a high standard of living with much lower environmental impacts". All resources are sustainably managed, from raw materials to energy, water, air, land and soil.

The European Innovation Partnership on Raw Material (EIP), furthermore, aims to help raise industry's contribution to the EU GDP to around 20% by 2020 and plays an important role in meeting the objectives of the flagship European Commission initiatives 'Innovation Union' and 'Resource Efficient Europe'. Its objective is ensuring the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole. The EIP targets non-energy, non-agricultural raw materials and many of these are vital inputs for innovative technologies and offer environmentally-friendly, clean-technology applications. They are also essential for the manufacture of the new and innovative products required by our modern society, such as batteries for electric cars, photovoltaic systems and devices for wind turbines, and is thus highly complementary to ZeroWIN objectives.

The more recent circular economy concept supports the delivery of the above-mentioned EU policies. A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which resources are kept in use for as long as possible, extracting the maximum value from them whilst in use, then recovering and regenerating products and materials at the end of each service life. Thus, the concept also includes product design for durability, disassembly and refurbishment, or D4R within the ZeroWIN framework; cascading products and materials through different applications before their end of life even across different value chains; and the elimination of the use of toxic elements in products.

Given our rapid depletion of resources, especially raw materials, and Europe's increasing waste generation, it is time to ask: what are the best ways to encourage resource recovery and recycling to get to 'zero waste'? European waste policy has prioritized waste

[1] www.zerowin.eu

prevention through a number of measures, its adequate integration by industry and in the waste sector is still at an early stage though.

2.1 Key determinants to industrial networks

Discussions with the ZeroWIN case studies as well as feedback from the stakeholder consultations have shown that there are a couple of key constitutive factors determining the applicability and implementation of industrial networks. The underlying barriers and recommendations are of more general nature and apply across the ZeroWIN sectors. However, they seem to be determinant to hindering or supporting the creation of industrial networks as such and therefore require strategic policy responses as well, though being general in nature, but reconfirmed by the ZeroWIN project once again.

Key determinants:

1) **Standardisation and material quality**

Feedback from the ZeroWIN industrial case studies has shown that, across all sectors, one of the major barriers for stakeholders to engage in industrial networks is the perception that products of lower quality may result from the use of recycled and reused parts and components. Quality tolerance has been determined as a crucial parameter for industrial networking. A key factor is the quality standard and the guarantee of the lasting performance which needs to be formally ensured just as in the case of the original materials or components.

A *European standard for secondary material, components and products* would help to ensure the reliability of material components and counteract this fear and skepticism. To take this one step further, the *increased use of standardized components* would generally increase the exchangeability of items in the production, installation, repair, re-use and recycling phases. Both the photovoltaic and IT industry, in particular, would benefit from such standardization and exchangeability of e.g. parts, plugs and interfaces.

From the construction case study work, it can be concluded that certification schemes and standards are important to make sure materials generated from demolition projects are fit for purpose when reused. There is a need to raise awareness and provide information to build confidence in the industry. *Increasing awareness of existing publicly available standards and quality protocols* that have been developed for the incorporation of recycled materials into new products and of the option for reused products to be certified for reuse will increase the willingness of construction companies to specify reused materials and increase the willingness of demolition companies to segregate the materials for reuse. Procedures to ensure quality of secondary materials and components need to be further developed to facilitate higher resource efficiency.

2) Economic benefits

Economics are the key driver to industrial networks. Actors will only engage in an industrial network if the industrial symbiosis is viable economically. The case studies showed that industrial networking is only likely to be accepted and implemented if it comes with revenues (or if it emerges from contractual or legal obligations).

In particular for the construction and demolition sector, the high cost of sustainable alternative materials and technologies can prove to be an inhibiting factor in their application. Innovative products or techniques can be more expensive than traditional practices. The economic climate is forcing industry to choose costs reductions over the best environmental option.

The deviation of waste streams from landfill to recyclers normally induces cost advantages; therefore, within the ZeroWIN project framework the stakeholders generally accepted the measures proposed, unless additional costs were associated with their implementation. *Rising landfill costs*, even though already a widely implemented legislative mechanism, was stressed again by the cases as being an effective measure supporting more reuse and recycling and respectively industrial networking as such. *Lower taxes on sustainable materials*, which again need viable EU-wide certification schemes, would support their use. Also *green public procurement* should be a helpful way to overcome the higher costs of environmentally sound materials and products.

It is important to convince industry and *foster industry trust in existing industrial networks*, to support industrial symbiosis initiatives and use successful local, regional and national cases to market their economic benefits and showcase best practices – and reduce the uncertainty of actors to be doing something illegal. On top of this, as shown by the ZerowIN case studies 1 and 3, *consumer education on the environmental, social and financial benefits of reuse* is necessary to create a market and generate demand for reused products and overcome market barriers. Same as the above landfill bans, *environmental taxation* would be beneficial. As the D4R laptop has much reduced CO2 and waste associated with it, taxes on CO2 and waste would give it a comparative advantage in the market place. *Reducing Value Added Tax on reused products* (as tax applied already when bought by the first user) was proposed as a measure to trigger consumer interest.

3) Access to information and material

Matching supply of secondary products with the demand side, in terms of both quantity and quality is a prerequisite for the establishment of industrial networks. ZeroWINs Work Package 6A was concerned with the development and exploitation of various potential interactions between industrial entities, with a main focus on resource exchange.

Information on the quality of secondary materials required for specific manufacturing processes is often unavailable, more transparency is needed in the waste management sector. Once the quality criteria are determined for the generated by-products or other secondary materials, the information is to be made available to the potential network partners. Within the ZeroWIN project, the *Resource Exchange Platform* was developed under case study 3 as an internet based portal which enables sharing the information on available or demanded secondary products among potential business partners. A platform as the RXP can be a good tool to support a facilitated network of initiatives, as introduced below (see 5).

4) By-product recognition

One of the key stumbling blocks to realizing zero waste in industrial networks is a lack of clarity regarding the definition of the terms “waste” vs. “product” and an inconsistent interpretation and implementation of the Waste Framework Directive (and other) across Member States. This lack of clarity often leads to significant administrative burdens (and respective costs) associated with turning waste materials into new production cycles.

European Union Member States’ legislation needs to impose a clear and harmonized definition of waste and end-of-waste status and simplify the recognition of by-products to facilitate the legal exchange of materials. Much work was already done towards this aim. *End-of-waste criteria* being developed – and in some cases already published – in the context of Waste Framework Directive will further promote common approaches and downstream markets for recovered fractions. *Mechanisms to simplify the procedures related to the certification of secondary materials / recognition of by-products* should be developed and tested, in particular for well-known streams which do not pose a threat to the environment (e.g. aggregates, wood) procedures should be simplified.

5) Facilitation of networks

All the ZeroWIN case studies were facilitated industrial networks. It generally seems easier to establish an industrial network when an external agent acts as a facilitator. The main task of a facilitator is to identify potentials for industrial networking and analyse the material flows, in order to detect possibilities for material exchanges and substitutions with other economic activities in the surroundings; Moreover, the facilitator promotes the contacts, suggests solutions for emerging problems, and evaluates the progress within an established network.

ZeroWIN has proven the facilitated network as a good example to be followed by industry, especially as the economic benefits are not directly obvious in the first instance. We recommend *installing facilitating bodies in all EU countries*, taking up the UK example, developing National Industrial Symbiosis Programmes[2] in all EU countries. These facilitating bodies should provide a good practice example and reveal the benefits of developing industrial networks. To take this further, the *creation of a facilitated network of initiatives on a European level* would be extremely supporting to the larger implementation of industrial networks (which then would also provide for a European information exchange on available material).

[2] See http://www.nispnetwork.com/

For the construction and demolition sector, it is difficult to establish stable industrial networking relations, as these relationships are normally limited to a specific project (and site) only. Having permanent networks, respectively facilitating bodies as introduced above, for material reuse/recycling which also maintains contacts with related industries and supports with setting up needed infrastructure and logistics, is recommended.

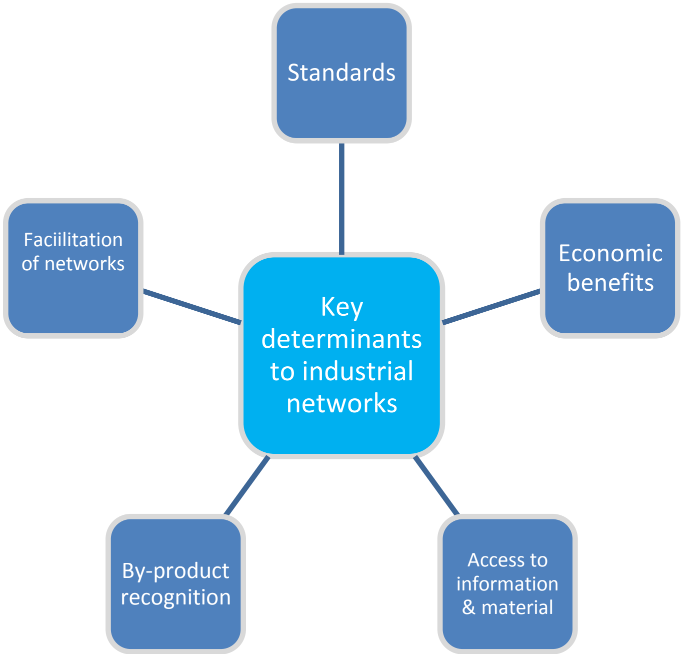

Figure 3: Key determinants to industrial networks

2.2 Barriers and recommended policy changes for the ZeroWIN case studies

In addition to the above mentioned overall determinants, the following section presents a selection of key barriers and recommendations which have been identified specifically from the ten ZeroWIN industrial case studies. It is important to note that this only presents a selection. The barriers and recommendations presented were chosen according to their specifics for the individual cases and according to their potential impact. For a more detailed report on the implementation of the case studies and identified barriers see ZeroWIN deliverable D6A3 “Final Case Reports For All Networks / Pilot Applications” accessible at www.zerowin.eu and Annex 1.

2.2.1 Construction and demolition

ZeroWIN comprised five case studies in the area of construction and demolition, targeted at implementing zero waste strategies in new construction projects (*CS4: Resource Efficiency Construction Networks in the UK*, *CS5: Resource Efficiency Construction Networks in Portugal* and *CS6: New Construction Schwabinger Tor*) as well as in demolition (*CS7: Demolition of End-of-Life buildings in the UK and CS8: Demolition of End-of-Life buildings* *in Portugal*) and refurbishment (*CS6: Refurbishment of Deutsche Bank´s Head Offic*e) projects.

CS4 was carried out on three construction sites in the UK, with the site 3 having the highest environmental benefits, as it was a 'design and build' project where construction materials and methods, transport, energy and water supply could still be influenced and increased sustainable procurement of goods and services led to a reduction of resource use and overall environmental impacts.

CS5 was a large-scale public construction project in Portugal. Considering the significant gap that exists between the planning and design and the execution stage of a construction work, setting the focus of the project on the execution phase did not allow in the CS5 the integration of the planning phase into the case study. The ZeroWIN environmental targets were met by separating waste outputs and identifying end markets for their reuse and recycling.

CS6 is focused at improving the logistics around two sites in Germany. An optimized logistical supply chain of delivery ("just-in-time delivery") and disposal as well as waste separation at the source on site were the two key factors determining the success of reuse and recycling strategies.

CS7 tracked progress towards sustainable best practice on four individual demolition sites in the UK coming from two building eras: pre 1950 and 1950s to 1980s. Key measures included a pre-demolition audit including a time plan of demolition activities to support selective demolition and allow on-site segregation and more reuse and recycling (even with limited space), developing opportunities for reuse and recycling of the output material, to a much lesser extent, by selecting alternative input materials and optimise logistics for waste management.

CS8 targeted three demolition sites in Portugal. Measures comprised the deviation of material from landfill through pre-demolition audit and selective demolition plan and the development of an electronic tool to support the planning of zero waste sites.

1. Low embracement of pre-demolition plans / waste management plans

One of the key tools used by all the construction and demolition case studies was the implementation of a pre-demolition audit and selective demolition plan, respectively a site waste management plan. To facilitate the segregation of materials it is important to identify the key material waste streams that will be generated on-site, prior to project start. The best and most widely used tool to achieve this is a waste management plan, or in the case of demolitions, a pre-demolition audit.

At the point in time, all construction projects in England worth over £300,000 were required to have a Site Waste Management Plan (SWMP) in place before a project could begin. At the end of the ZeroWIN project though the Site Waste Management Plans Regulations

2008 were repealed, with the British government hoping the de-regulation will save money for the businesses obligated by the law and that businesses will use the SWMPs on a voluntary basis as tool to enhance resource efficiency. Even though practice has shown that industry has not fully embraced the use of waste management plans, the ZeroWIN C&D cases consider waste management plans respectively pre-demolition audits as an excellent tool for estimating waste arisings and planning disposal routes as it classifies all materials into reclaimable (reusable), recyclable, hazardous and only suitable for landfill.

Under the existing average framework conditions selective demolition is usually not attractive for industry. An average-based scenario usually gives economical preference to traditional demolition, which generates a huge quantity of mixed wastes, over selective demolition, as the latter is much more time- and thus cost-intense. This is aggravated by time pressure on construction projects and the need for respective storage places. In the ZeroWIN cases, an inventory was used to assess the most appropriate method of deconstruction to maximise reuse and recycling opportunities and match materials to local reuse centres and recyclers. New industrial partners were attracted by the availability of clean, segregated by-products without the intermediate step of a waste sorting and recovery/recycling company. The deviation of waste streams from landfill to recyclers normally induces cost advantages. Therefore, the stakeholders generally accepted the measures proposed. The high quality of waste materials also enabled a less energy intensive and more effective recycling process.

Firstly, policy recommendations would thus target public demolition and construction projects and implementing legislation (on a national level) that requires all public construction and demolition projects to undertake a *pre-demolition audit, respectively waste management plan* (produce a reuse and recycling plan) prior to planning permission being granted(for all Member States). The key to overcome high costs of selective deconstruction is to highlight the income that can be generated by reclaiming materials, potentially supported by increasing prices for landfill disposal.

It is important to note though, that, as practice in e.g. the UK has shown, these measures could only work if there is *sufficient funding steered towards monitoring and policing*. Further, as done by the research teams in the case studies, associations or other relevant organisations should be tasked to *offer training about selective demolition* and material management and develop the experience of the staff involved.

There are also *resource efficiency drivers for the industry through accreditation schemes* like the Code for Sustainable Homes and Build Research Establishments Environmental Methodology (BREEAM). Each scheme provides credits for implementing a SWMP that meets certain minimisation, reuse and recycling targets. There are also credits available through BREEAM for undertaking pre-demolition and pre-refurbishment audits. This should be encouraged.

2. **Long time span between design and construction of buildings**

For public buildings in particular, the tender process, prescribed by legislation, results in a lengthy delay between the design and construction phases. Thus, the builder is normally not involved in the design phase and has little ability to change the materials, equipment and techniques set by the architects in the design stage. Cases study work has proven that – same as for the constructor - architects or designers are oftentimes reluctant to include sustainable or secondary products. The key to bridging this gap is an early intervention into the decision process, through early client and stakeholder engagement.

On a policy level, one of the key recommendations made was to *include the specification of sustainable or secondary material in public procurement tenders*, potentially also to award more *“design-and-built” contracts in public procurement*. Greater reuse rates could be encouraged by making the use of reused or recycled materials in the construction industry a criterion for the evaluation of public tenders. Producers of construction materials (e.g. cork products) are already engaged in getting an Environmental Product Declaration[3], which could ease the selection of which products to specify. This would encourage project professionals to think about these aspects in the design stage and would increase the likelihood that planners (local authorities/end-users/architects) would be more open to incorporating the use of sustainable materials and to consider input substitution with by-products, recycled materials or materials whose by-products have a high reuse potential in other processes. Already at the stage of university training, architects and designers need to be sensitized for these issues. Universities need to reflect a *life-cycle approach in their design curriculum* which explicitly takes on end-of-life aspects.

Further, the cases recommend that *policy should work with building certification/ accreditation schemes* (which are voluntary schemes as of now) as to schemes should provide credits for the use of sustainable or secondary materials. Major achievements have already been made in the construction sector in the area of energy performance; however, there is room for improvement to steer certification towards a stronger inclusion of recovered materials and support for industrial networks. This could either be achieved through implementing a new certification system or adjusting existing certifications systems as LEED by the U.S., Green Building Council, BREEAM in the U.K. or DGNB in Germany to support industrial networking (and thus provide an argument to the owner of a construction project for creating an industrial network). To specifically encourage reuse, *double counting of credits for reuse* as compared to recycling could be awarded.

3. **Lacking support of public authorities**

The public authorities are the biggest awarding authority in the construction and demolition sector. A key barrier is lacking public support in introducing recycled materials to the market and by this also building confidence into the quality. If the public authorities as

[3] An Environmental Product Declaration, EPD, is a verified document that reports environmental data of products based on life cycle assessment (LCA) and other relevant information and in accordance with the international standard ISO 14025 (Type III Environmental Declarations).

biggest consumer are not using these materials why should others? Therefore, they can take a special role in moving towards a resource-efficient Europe, as stressed under the 'A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy' which provides a long-term framework which aims to increase recycling rates, also promoting research for recycling. Thus, support the development of sustainable materials and buildings by *incorporating specific requirements in application procedures for public/EU funding (implement green procurement)*. Against the volume of public tenders, this would have a substantial impact. This would need to be supported by respective quality standards and certifications, as already introduced in 2.1, to avoid lock-in effects due to deficient material.

The following table shortly summarized the barriers and recommendations as introduced above.

Further, a brief impact assessment is performed to allow for a comparison of the different options. Please note that the impact assessment is only presented for those options mentioned under 'legislative area'. Voluntary endeavours are not considered in the impact assessment. In line with the objectives of ZeroWIN, the environmental impacts look at a potential reduction in greenhouse gas emissions, increase in reuse and recycling rates and a reduction in the use of fresh water. For economic impacts, the cost implications for the European Union, its Member States or industry are reviewed. Social impacts focus on job creation or a higher awareness on the issue by the general public. Lastly, general issues look at whether or not the implementation of the respective option would require a legislative change and whether it is practicable and focused and consistent with existing EU legislation.

Table 1: Summary of barriers and recommendations for the construction and demolition case studies

Barrier	Recommendation	Legislative area	Other area
Low embracement by industry of pre-demolition plans / site waste management plans; No legal obligation on a Europe-wide level	Mandatory pre-demolition audits / site waste management plans	Waste Framework Directive, national implementations	
	Supporting measures: - Steer funding towards monitoring and policing the preparation and implementation of pre-demolition plans / site waste management plans - Steer funding towards industry training on on-site practices, sustainable materials, products - Increase landfill costs	Landfill Directive	
	All building certification/accreditation schemes to provide credits for undertaking a SWMP and a pre-demolition/pre-refurbishment audit		Voluntary building accreditation / certification schemes

Long time span between design and construction of buildings, low acceptance of sustainable materials by architects	Universities to reflect a life-cycle approach in their design curriculum which explicitly takes on end-of-life aspects		University statutes
	Public tenders should include the specification of sustainable or secondary material; to award more design and built contracts in public procurement	Green Public Procurement*	
	All building certification/accreditation schemes to provide credits for the use of sustainable or secondary materials		Voluntary building accreditation / certification schemes
Lacking support/ initiative of public authorities	All public tenders should include the specification of sustainable or secondary material; - supported by quality standards (see chapter 2.1)	Green Public Procurement*	

* without mandatory implementation of GPP and binding targets, its efficacy is uncertain and many of the actions remain at the discretion of Member States

CONSTRUCTION & DEMOLITION [ZeroWIN industrial cases 4-8]	*Barrier: Low embracement of pre-demolition plans / site waste management plans*		*Barrier: Long time span between design and construction of buildings, low acceptance of sustainable materials by architects*	*Barrier: Lacking support/ initiative of the public authorities*
	Mandatory pre-demolition audits / site waste management plans	**Rise of landfill costs**	**Green public procurement: Public tenders to (i) include the specification of sustainable or secondary material and (ii) to award more design and build contracts**	**Green public procurement: Public tenders to include the specification of sustainable or secondary material; (supported by quality standards)**
Environmental impacts				
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	++	++	++	++
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	++	++	++	++
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	0	0	+	+
Economic impacts				
Implementation costs for European Union ***[magnitude: 0, +, ++]***	0	0	0	0
Implementation costs for Member States ***[magnitude: 0, +, ++]***	++ (enforcement)	0	+	+
Implementation costs for industry ***[magnitude: 0, +, ++]***	**	++	0	0
Social impacts				
Effects on job creation **[magnitude: 0, +, ++]**	+	0	0	0
Higher public awareness on issue ***[magnitude: 0, +, ++]***	++	++	++	++
General Issues				
Legislative change needed? ***[Y: yes / N: no]***	Y	Y	Y	Y
Practicality ***[Y: yes / N: no]***	Y	Y	? (GPP only voluntary)	? (GPP only voluntary)

Table 2: Short policy option impact assessment – construction and demolition

(For a list of measures including voluntary approaches see Table 1 above; For a list of key determinants see chapter 2.1)

2.2.2 ICT reuse

Reuse is integral to achieving the goal of zero waste. Reuse – when environmentally-superior to material recycling – is a necessary part of overall waste reduction, as laid down in the Waste Framework Directive[4], the 3R Concept and elsewhere. However, in particular for the electronics sector, current legislation does not sufficiently promote reuse, but mainly material recycling. The following section presents barriers and recommendations from the ZeroWIN case studies *CS1: Implementation of design recommendations in hightech products: the D4R laptop, CS3: regional ReUse network for ICT products around Berlin* and *CS10 Business to Business EEE Industrial Networks* which research industrial networks related to reuse of Information and Communication Technology (ICT) equipment.

CS1 in manufacturing manufacture a universal shell composed of a universal motherboard and a 6 cell lithium battery encapsulated in a wooden housing structure. The universal shell is capable of accepting new primary system components and also has the ability to integrate various diverse parts and components (and parts and components of different specifications). Key measures to reach the ZeroWIN environmental targets comprised D4R strategies (targeting minimised production waste, lifetime extension, easy repair and upgradability, disassembly, collection), the take back business model (leasing) and by-product parts for production sourced from industrial network partners via the Resource Exchange Platform.

CS3 targeted the extension of the existing ReUse ICT network “ReUse-Computer e.V.” (by increasing the re-use stream of ICT equipment and extending its activities from a regional to the European level). The Resource Exchange Platform (RXP) is an essential outcome, as introduced above of CS3. It provides additional business opportunities through clustering of re-use firms and allows regional transfer of the ReUse ICT concept, the inclusion of further product categories and the affiliation of additional service offers (e.g. transportation of re-use or end-of-life products, take-back, service instead of sales). Within CS3 technical guidelines for the refurbishment process and a marketing concept were also developed to guide reuse companies and start-ups.

CS10 researched the current situation of used Business to Business (B2B) EEE collection and treatment in EU member states and propose improvements, including policy recommendations. Sample countries for data collection were UK, Austria, Germany, Romania and Spain.

1. **Supply uncertainties in terms of quality, timing, and quantity**

One of the key barriers identified are supply uncertainties in terms of quality, timing, and quantity of returned products. The D4R network scenario and business case, as proposed in case study 1, is only economically viable if there is an adequate supply of quality used

[4] Directive 2008/98/EC on waste

primary computer system components to MicroPro computers to populate the universal shell. Within ZeroWIN, this was addressed by the Resource Exchange Platform (RXP)[5] which was developed under case study 3. The RXP allows network partners to view the quality, timing, and quantity volumes of primary system computer parts or materials in the network at any given time. Already in the initial phase since its operation start the RXP has proven to increase the availability of components and products for the industrial network. On a medium-to long-term basis, the platform should be further expanded by taking on new network partners, and simultaneously the volumes dealt with increased.

Knowing what quantities of products and materials are available and also in what location they are available is important for the success of the proposed D4R industrial network. ZeroWIN has researched Radio Frequency Identification (RFID) used in conjunction with the appropriate architectural frameworks to address this issue through increasing the visibility of material in industrial networks. Suitable tags and also optimal transponder positions to enable reliable end-of-life identification for laptops, desktops and LCD products have been demonstrated through an investigation of a series of end-of-life use case scenarios[6].

GS1 EPCglobal[7] is currently in the process of developing a *Discovery Services Standard* which would allow obtaining all relevant visibility data, of which a party is authorized, when some of that data is under the control of other parties with whom no prior business relationship exists. The case study team recommends that such a standard should be expedited in order to enable the use of RFID in industrial networks. Policy should *push the voluntary industry use of RFID tags in electronics* as part of a comprehensive life cycle management initiative. Further discussions should be taken up in relevant industry associations like Digital Europe[8].

Another potential implementation for RFID technology, which is not linked to the constraint of supply uncertainties, but also relevant to the ZeroWIN CS1 – and is therefore mentioned here -, is the extraction of lifetime usage data via RFID. CS1 has stressed that testing to assess quality of secondhand components is time-intense, thus impacting again the underlying business case of the industrial network. Condition monitoring technologies can serve to enhance the profitability of triage operations, extraction of lifetime usage data via RFID (as a further development of the condition monitoring concept) can provide an efficient cost effective means of testing of used systems before streamlining respective system parts to the most appropriate end-of-life activity. Case study members thus suggest

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[5] http://www.trxp.eu

6 For more details see ZeroWIN Deliverable 2.1: Feasibility Study on Technologies to facilitate Product Identification for various IPR Models and a Technology Roadmap for RFID in Waste Management, accessible at www.zerowin.eu.

[7] GS1 is an international not-for-profit association dedicated to the development and implementation of supply chain standards across the world. GS1 EPCglobal is the respective suite of RFID standards. See http://www.gs1.org/epcglobal/about.

[8] http://www.digitaleurope.org/

steering European Union funding towards further research on the extraction of lifetime usage data via RFID and comprehensive field trials.

The constraint of quality assurance can be addressed by the aforementioned *standard for second-hand components*, so that the reliability of parts and components can be ensured. *Separate reuse and recycling targets in the WEEE Directive*[9] for B2B and B2C would further increase the availability of returned products and thus parts and components for reuse. As stated in the WEEE recast, it is recommended that the European Parliament and the Council re-examine the possibility of setting separate targets for WEEE to be prepared for re-use. (This is essentially also an issue of value-conserving collection and transport for high-value IT equipment. There is research available on the economic and logistical constraints and options of such, however further unbiased research and trials are recommended.)

As introduced in the section on key determinants to industrial networking, the definition of "waste" vs. "product" can also cause a substantial barrier, as it is now substantially discussed under the international regime of the Basel Convention and elsewhere. A problem is created for reuse enterprises when used PC's are considered "waste" in that they can only be shipped and treated by accredited waste collection agencies or compliance schemes. *Accredited reuse/D4R industrial network members should be given a green pass as a trusted destination for such material*.

2. **Lacking accounting system for B2B EEE**

Business-to-business (B2B) waste electrical and electronic equipment poses a huge potential for reuse, and correspondingly towards an improved resource efficiency. B2B waste electrical and electronic equipment is regulated in the WEEE Directive. However, as research under ZeroWINs case study 10 concluded, the majority of B2B WEEE flows into independent networks of collectors for treatment and value recovery. These channels or networks are not accounted for in the WEEE Directive. Producer Responsibility Organisations report the amount of WEEE processed which mainly contributes to the European Union statistics. However, other organisations which collect and treat B2B WEEE are under no obligation to do so.

Generally, a *take-back and financing system based on WEEE arising* is recommended over the current practice based on sales, as it would help differentiate between business-to-consumer (B2C) and B2B equipment, as they arise at different points in the waste stream.

The research results of CS10 conclude that the fact that private organisations currently exploit WEEE for financial gain does not automatically have negative implications in terms of the environmental and social impacts of WEEE. Providing all WEEE, regardless of quality, can be accounted for and it is treated to an acceptable standard, there is no reason

[9] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE)

to interfere in the existing competitive collection and treatment industry. Should current actors be given a mechanism to declare their share of the market (to enable the assurance of adequate coverage in total) and treat to an acceptable standard, suitable collection and treatment networks for B2B WEEE could be in place already.

However, a solution which addresses these actors needs to be developed which considers both the drivers of the system, the value in reuse and resource exploitation, and the barriers which effect decision making. Placing too much of a burden on reporting could make collection and processing unprofitable and eventually result in low collection rates and no reuse.

CS10 recommends that the *collection rates of the largest collecting organisations* are officially confirmed. Data can be collected as simple mass data to determine an organisation's total collection share from the sales figures provided by manufacturers for WEEE Directive reporting (usually on an annual basis). This could potentially be supported by *third party verification* to prove the accurateness of figures and in an anonymous form to address commercial data sensitivity. Such an accounting system should not place such an administrative burden on industry, as that the practice becomes unattractive. This essentially also relates to insecurities on the definition of "used electrical and electronic equipment" and "waste electrical and electronic equipment". The case study team recommends follow-on work to clarify the extent to which this nomenclature issue is (only) one of popular usage or the uncertainty is caused by unharmonised use in Member States' legislation.

Again, the following summarizes the key barriers as well recommendations made for the IT reuse sector. An impact assessment (comprising the legal options only) follows in Table 4.

Table 3: Summary of barriers and recommendations for the IT reuse case studies

Barrier	Recommendation	Legislative area	Other option
Supply uncertainties in terms of quality, timing, and quantity	Establish European standard for second-hand components/products	European standardisation organisations (ESO), national standardisation bodies ➢ Regulation (EU) No 1025/2012 of 25 October 2012 on European standardisation	
	Separate reuse and recycling targets in the WEEE Directive	Directive 2012/19/EU	
	Accredited reuse/D4R industrial network members should be given a green pass as a trusted destination for waste material	Directive 2012/19/EU (Clearing House for Competent Authority)	

	Completion of Discovery Services Standards to enable the use of RFID in industrial networks		GS1 EPCglobal
	RFID tags to be integrated into electronics as part of a comprehensive life cycle management initiative		Voluntary industry endeavor; policy dialogue ➔ Digital Europe
Lacking accounting system for B2B EEE	Mandatory recording of collection rates of large B2B collecting organisations	Directive 2012/19/EU	
	Supported by: -third-party verification		Subcontractors for Clearing House
	Base system on WEEE arising to help differentiate between B2B and B2C	Directive 2012/19/EU	

IT REUSE [ZeroWIN industrial cases 1,3,10]	*Barrier: Supply uncertainties in terms of quality, timing, and quantity*			*Barrier: Lacking accounting system for B2B EEE*	
	Establish standard for second-hand components	**Separate reuse and recycling targets in the WEEE Directive**	**Accredited reuse /D4R industrial network members to be given a green pass as a trusted destination for waste material**	**Mandatory recording of collection rates of large B2B collecting organisations**	**Base system on WEEE arising to help differentiate between B2B and B2C**
Environmental impacts					
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	++	++	+	NA	NA
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	++	++	++ (reuse)	NA	NA
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	++	+	NA	NA
Economic impacts					
Implementation costs for European Union ***[magnitude: 0, +, ++]***	0	0	0	0	+
Implementation costs for Member States ***[magnitude: 0, +, ++]***	++	0	+	+	++
Implementation costs for industry ***[magnitude: 0, +, ++]***	+	+	0	+	0
Social impacts					
Effects on job creation **[magnitude: 0, +, ++]**	0	++	+	0	0
Higher public awareness on issue ***[magnitude: 0, +, ++]***	++	++	++	++	0
General issues					
Legislative change needed? ***[Y: yes / N: no]***	N	Y	N	Y	Y
Practicality ***[Y: yes / N: no]***	Y	Y	Y	Y	Y

Table 4: Short policy option impact assessment – IT reuse

(For a list of measures including voluntary approaches see Table 3 above; For a list of key determinants see chapter 2.1)

2.2.3 Photovoltaics

The recast of the WEEE Directive has brought with it a major change for the photovoltaics (PV) industry. Previously exempt from WEEE recycling obligations, the recast now includes photovoltaics under Category 4 (consumer equipment and photovoltaic panels) and Category 5 (small equipment with integrated photovoltaic panels), meaning that producers of photovoltaic panel systems will be obligated to ensure the collection and recovery of end-of-life photovoltaic products. In this context it is important to note that CS2 considers the current collection target of 65% of the items put on the market in the last three years as not realistic for PV panels (with lifetimes of about 20 – 30 years) and suggests to *base the collection target on the generation of waste PV panels*. However, given that PVs contain a multitude of resources also used in the manufacturing of other goods and that they now have to comply with the rules applicable for the wide range of EEE, this opens up potentials for industrial networking.

ZeroWINs case study *CS2: Implementation of design recommendations in high-tech products: D4R photovoltaic system* comprised the elaboration of a detailed PV complete system concept, the development of a D4R power conditioning prototype and the installation and start-up of both a grid-connected and a stand-alone PV system in Spain.[10] Key tools to address the ZeroWIN environmental targets were the improvement of the performance ratio of the overall system and increasing the operational lifetime of the different components (which will enable the reduction of the use of batteries and PV modules - the main contributors of the PV system environmental impacts), and the use of Li-ion batteries. Additionally, the power conditioning was developed following D4R criteria.

Major barriers identified under CS2 very much argue for the key determinants (and recommendations) as mentioned under 2.1, specifically the points made on material quality and standardization as well as higher costs of regenerated parts compared to primary products. As for the power conditioning prototype, the high requirements for quality and reliability and the fear of potential quality losses of refurbished parts or recycled material content as well as the lack of performance guarantees make the engagement of stakeholders difficult.

1. **Underachieved use of off-specifications and second-life PV modules**

One of the key measures to achieve the ZeroWIN environmental targets comprises *the use of off-specification and second-life PV modules*. Looking at the environmental impacts of PV systems, the production phase is the most influential. Within the production phase of the PV module, the processes associated to the silicon raw material, wafer and cell manufacturing have the highest environmental impacts. Therefore, the identification of

[10] The grid-connected system is a PV system which is able to inject and export the electricity into the utility grid, the stand-alone system is a PV system which cannot inject into the grid, and all the PV generation is consumed on-site. The grid then is considered as a back-up system, that is, electricity is taken from the grid when the batteries are discharged and in the event of poor PV performance.

reuse and recycling of PV modules has been in the focus of CS2. PV systems were installed that consist 100% of off-specifications or modules (with visual defects) that normally would have entered the waste stream, thus substantially decreasing the consumption of raw materials.

The main barrier associated to the use of off-specification PV modules is that practice has shown that manufacturers are not keen on selling off-specification or reused modules, as they fear this would “cannibalize” their own sales. Common perception is that selling lower quality products will eventually destroy existing markets. ZeroWINs CS2 suggests to *introduce these modules in areas or projects where primary products are too expensive* and it would otherwise not be feasible to install a PV system in the first place (potentially resulting in less environmental benefits of a project overall). Case study members recommend setting a *minimum reuse target for end-of-life PV systems* in the WEEE Directive as a tool to induce alternative application channels for reused and off-specification PV modules.

The lifetime of a photovoltaics installation is approximately 25 years and the photovoltaics plant has to ensure the maximum electricity generation during its entire lifetime. That means in practice the PV modules have to comply with high quality requirements and ensure durability. To engage PV systems integrators or operators in the use of off-specifications and second-hand hand modules, CS2 proposes to define and introduce specific *guarantee schemes* for both (i) off-specifications and (ii) secondary/reused PV modules and components. Such guarantees should be developed in a joint effort of industry (manufacturers and solar system installers) and policy and target materials/product warranties (which can be awarded both by the manufacturer or the system installer), performance warranties by the manufacturer, or other warranties like e.g. for inverter- or battery-warranties. For second-hand modules, the average lifetime will naturally be shorter (approximately 10 years), so modules would have to be changed during the installation lifetime. The above mentioned guarantees can reflect such implications and specifics for off-specifications and secondary PV modules and still ensure a specified performance. In the medium- to long-term it will be important to take a corresponding discussion up in related fora, f.i. the European Photovoltaic Industry Association (EPIA).

In general, case study members recommend the *broader use of standardized components*. This would increase the exchangeability of items both in production, installation and repair and reuse. Furthermore, due to reduced variance of every standardized component, the effort for certification would also be reduced, which allows for an additional cost reduction. A potential mechanism to identify and select components or subsystems suitable for standardization is to place a *topic on standardization of components for PV systems (including identification of test procedures and respective protocols) under EU funding programmes* where appropriate.

To further support reuse of PV components or modules, specific *guidelines for the inspection, control and repair of PV modules* (or its parts) should be introduced. Simultaneously, as the PV industry is a relatively new sector, there is a need for BREFs

(BAT Reference Documents) on PV recycling highlighted by the EIPPCB (the European Integrated Pollution Prevention and Control Bureau).

Promoting the inclusion of reused or recycled material via *Green Public Procurement* is again seen as a tool to overcome the barrier that it is currently still easier and cheaper to buy a new product than make use of regenerated part and components due to the manufacturing chains of products and sub-products.

2. Low synergies in water and energy networks

Results across all ZeroWIN industrial cases have made difficulties obvious in reaching an overall reduction of 75% of fresh water use (also see the section on 'Outlook and further research needs'). Minimizing freshwater consumption and optimizing water networks in industrial processes can bring various synergies for the network partners. However, infrastructure and proximity can be a weak point, as longer distances between facilities directly result in higher costs that off-set the benefit of the initial synergy of exchanging water and in particular heat.

CS2 members propose to promote *industry clustering* and *common energy (mainly heat) and water servicing* (by sharing mini-grids of energy and water between neighbouring plants) - and the corresponding *facilitation of the administrative permitting*. As already introduced in chapter 2.1 on key determinants, specifically the point on the facilitation of networks, such a clustering and the respective common energy and water servicing will have to be guided by a facilitator. This can be done by national facilitating bodies or a specialized consultancy firm contracted by the higher-level agency that runs a cluster program. Herewith, Energy Service Companies (ESCOs) could also play a key role, as to incorporate the concept of industrial symbiosis, and the addition of water mini-grids in their work. An energy service company is a commercial or non-profit business providing a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. Key to this business model is the fact that ESCOs base their fee on the energy savings realized within a project thus achieving the highest efficiency is incentivised. *Further dialogue is thus needed with relevant bodies like the European Association of Energy Service Companies*[11].

The following two tables summarize the key barriers and recommendations made by the photovoltaics case study and present a short impact assessment of the proposed policy options. Voluntary approaches are again not reflected in the impact assessment.

Table 5: Summary of barriers and recommendations for the photovoltaics case study

Barrier	Recommendation	Legislative area	Other option
Underachieved use of off-specifications and second-life PV modules	Setting a minimum reuse target for end-of-life PV systems in the WEEE Directive	Directive 2012/19/EU	

[11] For more details see http://eu-esco.org/.

	Guarantee scheme for (i) off-specifications and (ii) second-life PV modules and components	Potentially also EU consumer law	Voluntary industry endeavor ➔ EPIA
	Support broader use of standardised components for PV systems	Place topic on standardization of components for PV systems under EU funding programmes (call for proposals)	
	Develop guidance documents on PV component / module reuse and PV recyling	European Integrated Pollution Prevention and Control Bureau	
	Promoting the inclusion of reused or off-specification PV components or panels in public installations	Green Public Procurement Programme*	
Low synergies in water and energy networks	Promote industry clustering and common water and heat servicing		Through national facilitating organisations or consultancy firms for high-level authority
	Supported by: facilitation of administrative permitting		
	ESCOs to incorporate / consider the concept of industrial symbiosis	Related to: ➔ Energy Performance of Buildings Directive, EPBD (Directive 2010/31/EU) ➔ Public Procurement PP (Directive 2004/18/EC) ➔ Eco-design of Energy-Related Products, EuP (Directive 2009/125/EC) ➔ Directive on energy efficiency, EED (Directive 2012/27/EU)	Voluntary industry endeavor

* without mandatory implementation of GPP and binding targets, its efficacy is uncertain and many of the actions remain at the discretion of Member States

PHOTOVOLTAICS [ZeroWIN industrial cases 1,3,10]	*Barrier: Underachieved use of off-specifications and second-life PV modules*					*Barrier: Low synergies in water and energy networks*
	Setting a minimum reuse target for end-of-life PV systems in the WEEE Directive	**Establish guarantee scheme for (i) off-specifications and (ii) second-life PV modules / components**	**Place topic on standardization of components for PV systems under EU funding programmes**	**Develop guidance documents on PV component / module reuse and PV recyling**	**Green public procurement: Promote the inclusion of reused or off-specification PV components or panels in public installations**	**Promote industry clustering and common water / heat servicing; Supported by corresponding facilitation of administrative permitting**
Environmental impacts						
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	++	++	NA	NA	++	++
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	++	++	NA	NA	++	0
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	+	NA	NA	+	++
Economic impacts						
Implementation costs for European Union ***[magnitude: 0, +, ++]***	0	+	++	+	0	0
Implementation costs for Member States ***[magnitude: 0, +, ++]***	0	0	0	0	++	+
Implementation costs for industry ***[magnitude: 0, +, ++]***	0	+	0	+	0	+
Social impacts						
Effects on job creation **[magnitude: 0, +, ++]**	0	0	0	0	0	+
Higher public awareness on issue ***[magnitude: 0, +, ++]***	++	+	+	+	++	++
General issues						
Legislative change needed? ***[Y: yes / N: no]***	Y	N	N	N	Y	N
Practicality ***[Y: yes / N: no]***	Y	Y	Y	Y	? (GPP only voluntary)	Y

Table 6: Short policy option impact assessment – photovoltaics

(For a list of measures including voluntary approaches see Table 5 above; For a list of key determinants see chapter 2.1)

2.2.4 Automotive

End-of-life vehicles (ELV) have become a global concern as automobiles have become popular worldwide. The European ELV Directive 2000/53/ES defines recovery, reuse and recycling targets for ELV by weight of the vehicle. Traditional recovery routes for ELV were metal-oriented due to high metal content in automobiles. Achievement of the ELV Directive targets demands that non-metal fractions are also recycled.

ZeroWINs *CS9: Glass-Fibre Enforced Plastics Recycling for a Security Relevant Component in the Automotive Industry* focusses on an industrial network for plastics recycling in the automotive sector. The control housing, a security relevant component, was chosen and high-tech primary plastics material was substituted by recyclate. CS9 shows the links of product development, production processes and the set-up of an appropriate industrial network.

The control housing was chosen because there is a traditional reluctance in the automotive industry to use recycled materials in functionally important components, in particular for safety-to-life parts or components. Thus, barriers to the use of recycled plastics comprise not only technical problems but also, as repeatedly stressed before, prejudices and insufficient knowledge within industry about the possible applications and properties of the recycled plastics towards their quality and durability.

The case study is of relevance to the automotive sector as it investigates improvements towards environmental protection as well as cost competitiveness and improving the resilience to fluctuations of oil respectively plastics prices.

The case study work did not provide specific policy recommendations. It is important to note that case study partner *Continental regards the existing legislative framework as sufficient and fully appropriate for the implementation of higher recycled contents in the automotive industry*. The automotive industry has already set up stringent standards applicable within the industry. It is further common practice that original equipment manufacturers include a statement in their purchase agreements that recycled materials should be preferred for the manufacture of components where appropriate - “where appropriate” is understood as, as also shown by this case study, a matter of technological innovation and sourcing, respectively availability of recycled materials.

One of the key technological barriers the case study faced was the long-term supply of the PET-GF35 recyclate, respectively PET-GF35 waste from defined sources, for the serial production of the control housings. Because the control housing is a component of high security relevance, the material quality and the durability are of crucial importance. The used recyclate, glass-fibre enforced plastics, has different material properties compared to virgin material, which enforces with every recycling cycle. To avoid uncontrollable changes in the material properties and to assure quality, Continental only uses virgin material which is recycled once for the recyclate for the control housing at the current stage of development. Therefore, the traceability is mandatory to ensure material quality for this specific application. Possible sources of the recyclate further have to guarantee the secure supply over a long period of time.[12] This aspect is in favour of industrial networks with more stable relations between the network partners than a market-based purchase of recyclate. As already introduced in chapter 2.1 on key determinants to industrial networks, quality tolerance has been determined as a crucial parameter for industrial networking. CS9 thus supports the call for a *European standard for 2nd-hand components (and fractions in recycling facilities)*. Sourcing the recyclate from end-of-life vehicles is as of current status not economically viable, due to the current common process of shredding end-of-life cars. Additional *research on traceability (e.g. through RFID tracking) as well as a change of the current recycling concept* of the major recyclers (more dismantling than shredding as the first step) would be necessary. At the moment, Continental sees no solution for overcoming this barrier and no additional legal instruments to address this were identified.

On a more general level, the case study members suggest *steering European Union funding towards more research in reuse and recycling technologies, the substitution of materials as well as the development of guidance on best available technologies (BAT) in research pilot projects*. By this case study, all technical preconditions (product development and recycling process, material specifications for recycling of glass-fibre enforced plastics) are made available. The technical barriers regarding the development of the control housing were solved within the case study. Supporting more research projects like ZeroWIN would enable the development of technical solutions, while at the same time proving the economic business case to *trigger industry interest and trust in industrial networks*.

Project partners at Continental have further made the experience that such *flagship projects* helped reduce prejudices against the use of plastic recyclates with the own employees. As introduced before, there is a tendency to use well-known virgin plastics at the level of the single engineer. The Continental-internal prejudices were eliminated by the careful choice of the application in the component control housing – which is in terms of security relevance one of the highest possible at Continental. In large socio-technical organizations - such as Continental - flagship projects are a vital means for introducing a change in thinking with the own employees. The case study work has proven that, if using a recyclate is possible for such a security relevant part like the braking system, its use can be expanded to other parts as well.

The above discussions are summarized in the following two tables:

[12] Continental develops control housings for OEMs adapting a 'control housing platform' to the individual customer specific adaptions. Such a platform is regularly used for a period of 14 years.

Table 7: Summary of barriers and recommendations for the automotive case study

Barrier	Recommendation	Legislative area	Other area
Long-term supply of recyclate for serial production of control housing	European standard for second-hand components (and fractions in recycling facilities)	European standardisation organisations (ESO), national standardisation bodies ➔ Regulation (EU) No 1025/2012 of 25 October 2012 on European standardisation	
Potential quality losses or lower material performance of recyclates and resulting industry scepticism	Steer EU funding towards more research in reuse and recycling technologies, the substitution of materials as well as the development of guidance on best available technologies (BAT) in research pilot projects (co-financing of flagship projects)	EU funding programme where appropriate	

AUTOMOTIVE **[ZeroWIN industrial case 9]**	***Barrier: Long-term supply of recyclate for serial production of control housing***	***Barrier: Potential quality losses or lower material performance of recyclates and resulting industry scepticism***
	European standard for second-hand components (and fractions in recycling facilities)	**Steer EU funding towards more research in reuse and recycling technologies, the substitution of materials as well as the development of guidance on best available technologies in research pilot projects**
Environmental impacts		
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	++	++ (indirect)
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	++	++ (indirect)
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	++ (indirect)
Economic impacts		
Implementation costs for European Union ***[magnitude: 0, +, ++]***	0	++
Implementation costs for Member States ***[magnitude: 0, +, ++]***	++	+
Implementation costs for industry ***[magnitude: 0, +, ++]***	+	0
Social impacts		
Effects on job creation **[magnitude: 0, +, ++]**	0	+
Higher public awareness on issue ***[magnitude: 0, +, ++]***	++	++
General issues		
Legislative change needed? ***[Y: yes / N: no]***	N	N
Practicality ***[Y: yes / N: no]***	Y	Y

Table 8: Short policy option impact assessment – automotive

(For a list of key determinants see chapter 2.1)

3. OUTLOOK AND FURTHER RESEARCH NEEDS

Industrial networking can create energy and material savings, a competitive advantage and new business opportunities for industry, and minimize waste and pollution. Stakeholder consultation shows that a lingering mental barrier among industry actors contributes to scepticism as to the benefits of industrial networking and hesitance to change their traditional operating way. Various policy barriers and drivers were identified by the ten ZeroWIN industrial case studies which are presented in this report.

Overall, all case studies have proven that industries can reduce greenhouse gas emissions by at least 30 per cent and can achieve a 70 per cent overall re-use and recycling rate for waste through successfully engaging in an industrial network. The reduction of freshwater-use, the third environmental target of the ZeroWIN project, could not be achieved in most cases. This should be further supported by the general development of infrastructure for grey water use. Such developments already take place in various industries, however, these industries should be better interconnected on the reuse of water. Here, the development of quality standards for various applications could be helpful. One has to note though, that this is rather limited to industrial parks, where all facilities are located close to each other and is more related to the manufacturing industry. In particular for the construction industry, as construction sites are only temporary, such an infrastructure development will not be economically viable. A tool to address this would be to develop standards on using lower quality water for various applications, potentially best available technology reference documents (BREFs) for individual industries, as such applications a very much industry-specific and we recommend further research.

Various other research needs have been identified which are presented in the following according to the ZeroWIN cases (construction and demolition, IT reuse, photovoltaics and automotive). These research needs should be reflected in terms of availability of European Union funding:

Construction and demolition

- Support demolition companies to identify reuse and recycling routes for modern multi-material or bonded materials; Further research is needed on specific material (e.g. PVC plastics and insulation materials) to identify new markets
- Potential of including sectors such as reclamation, salvage and waste companies as well as utility companies in future industrial networks (in conjunction with construction companies)
- Technical specifications of products and by-products in material manufacture in terms of product quality (ceramics, steel, glass, cement, concrete etc.)

ICT reuse

- Research and comprehensive field trials on the extraction of lifetime data via Radio Frequency Identification (RFID)

- Potential to apply RFID for an efficient take-back and recovery scheme in the management of end-of-liefe vehicles (including separation of electronics)
- Potential to apply RFID in buy back/deposit systems
- Logistical optimization: value conserving collection and transportation
- Warranty prolongation and other instruments that could promote high-quality, re-usable long-life products
- Behaviour research on consumer attitudes towards reused products
- Investigate alternative routes for B2B WEEE that were outside the scope of ZerowIN (including leakage into the B2C stream, landfill, illegal export and dumping)

Photovoltaics

- Research on the technology and infrastructure to make the recovery of silicon economically more efficient

Automotive

- Use of tracking technology (RFID) for identification and efficient management of plastics and other material (electronic components, metal alloys, etc.) in end-of-life vehicles
- Use of bioplastics in the automotive industry

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Sources include further references in their respective list of references.

ANNEX 1: COMPLETE LIST OF BARRIERS AND RECOMMENDATIONS ACROSS ZEROWIN CASES

Recommendation	Barrier	Sector
	Technological barriers	
EU standard for 2nd-hand components & products and enhancement of the use of standardized components	*Potential quality losses or lower material performance of recyclates or refurbished parts and components; Industry scepticism; Uncertainties regarding quality, timing and quantity of returned products or components for reuse*	IT, PV, C, A
Research in reuse and recycling technology as well as the usage of regenerated materials & Best Available Techniques (BATs) for reuse and recycling	*Potential quality losses or lower material performance of recyclates or refurbished parts and components; significant delays in passing on BATs to production processes*	IT, PV, C, A
Require producers to test components and provide information about the operative life of the component to refurbishers/reuse organizations (for warranty)	*Lacking insights, access to information*	IT
Guidelines for inspection, control and repair of photovoltaic modules	*Lacking guidance on inspection, control and repair of photovoltaics modules*	PV
Support for research and application of the recovery of silicon from photovoltaic modules (to enable the reuse of silicon)	*Limited recovery of silicon, as the current technology is too expensive*	PV
	Financial / Economic barriers	
Financial support of social enterprises active in refurbishment/reuse (e.g. through tax incentives, subsidies, through “welfare to work” funding for labour…)	*Lacking economic incentives to trigger a change from the traditional operating way; Daily changing commodity prices make it difficult to plan for reuse*	IT
Reduced VAT for reused products*	*Externalization of costs/high labour costs* ** (when buying a new product VAT is already paid, thus a recommendation would be to apply a reduced VAT of 7% for reused products to make these financially more attractive)*	IT
Enhance co-operation with producers, set up and enforce global labour standards / human rights / millenium development goals	*Externalization of costs/high labour costs hinder reuse*	IT
Promote industry clustering and common energy (mainly heat) and water servicing (by sharing mini-grids of energy and water between neighbouring plants) and the corresponding facilitation of permits/administration	*Difficult to transport water/energy (related streams) - higher costs that off-set the benefit of the synergy*	PV
Current regulatory changes in favour of Energy Service Companies (ESCOs) could incorporate also the concept of industrial symbiosis, and the addition of water mini-grids	*Difficult to transport water/energy (related streams) - higher costs that off-set the benefit of the synergy*	PV
Offer economic incentives: Enable the readaptation of machines and the production chain in manufacturing, making the photovoltaics recycling process more economically advantageous at a shorter term	*Expensive to adapt the production chain for use of recycled components or D4R design*	PV
Introduce off-specs photovoltaic modules in areas where primary products are too expensive	*Manufacturers are not keen on selling off-spec modules or reuse modules because both products would cannibalize their own sales*	PV

Charge a recycling fee to the manufacturers and the more difficult to recover/recycle, the higher the fare should be	*Low enhancement in D4R by WEEE: producers can join a collection scheme or fulfill the requirements themselves. Major decision driver is the cost*	PV
Landfill bans (or increase of landfill costs)	*Lacking economic incentives to trigger a change from the traditional operating way:* *construction material is relatively cheap, costs for dismantling, storage, cleaning etc. high;* *sustainable products more expensive than ordinary products;* *Transportation of by-products/wastes from one company to another*	C
Tax incentives / subsidies for use recovered materials	*Lacking economic incentives to trigger a change from the traditional operating way:* *construction material relatively cheap, costs for dismantling, storage, cleaning etc. high;* *sustainable products more expensive than ordinary products;* *Transportation of by-products/wastes from one company to another* *Expected higher costs of logistics of delivery during the construction and demolition on site (cause: higher operating costs)*	C
Induce less packaging/lighter packaging, forced take-back (e.g. pallets)	*High costs for managing packaging waste*	C
Elimination or decrease of costs for the recognition of a by-product and development of a more agile recognition process	*Most important: greyzone in Portugal, high administrative burden and costs associated with turning waste into by-product/end-of-waste status*	C
Finance pilot projects to prove economic benefits	*Costs associated with new technologies;* *Industry skepticism;* *Fear of lower quality of recyclates*	A
	Institutional / Organizational barriers	
Set separate reuse and recycling targets in the WEEE Directive (current national implementation)	*Reliability of material flows, i.e. the security of high-quality supply and access to waste when needed*	IT
Ensure reuse friendly collection for B2C equipment	*Reliability of material flows, i.e. the security of high-quality supply and access to waste when needed*	IT
Require separate and appropriate collection facilities for recycling and reuse	*"Reuse-unfriendly" take-back and collection at municipal collection sites (for B2C equipment)*	IT
Require municipalities to ensure that there is trained staff at municipal collection points for first inspection	*"Reuse-unfriendly" take-back and collection at municipal collection sites (for B2C equipment)*	IT
Require that compliance schemes work with suitable PAS 141 accredited reuse enterprises to meet reuse quotas	*Lobbying of compliance schemes and individual large (recycling / disposal) companies against new approaches like reuse*	IT
Require municipalities by law to guarantee reuse companies access to municipal collection points	*"Reuse-unfriendly" take-back and collection at municipal collection sites (for B2C equipment)*	IT
Education, access to information	*Planning process: "designers/architects establish framework contractual conditions (including environmental criteria)", which are difficult to change in construction phase;* *Low acceptance of planners (local authorities)/end-users/architects to accept sustainable materials;* *Industry sceptism towards industrial networks in practice (and reused parts*	C

	and components or regenerated materials/sustainable products	
Adjust building certification systems; **Mandatory certification system for any construction site**	*Room for improvement to steer building certification towards a stronger inclusion of recovered materials and support for industrial networks. This could either be achieved by implementing a new certification system or adjusting existing certifications systems as LEED BREEAM DGNB (and thus provide an argument to the owner of a construction project for creating an industrial network)*	C
Include mandatory requirements for use of regenerated /sustainable materials in public procurement	*Planning process: "designers/architects establish framework contractual conditions", difficult to change in construction phase;* *low acceptance of planners (local authorities)/end-users/architects to accept sustainable materials*	C
	Societal barriers	
Public Information Campaigns	*Consumer patterns ("I always need the newest product")*	IT
Steering of funding for circular economy and reused products	*Consumer patterns ("I always need the newest product")*	IT
Showcase best practices and provide advise on material reuse (e.g. Bioregional, UK)	*Industry skepticism*	C
	Legal / Political barriers	
Reuse bodies should be recognized as compliance schemes or should be able to set up own compliance schemes / Accredited reuse or d4r industrial network members should be given a green pass as a trusted *destination for such material	*Lack of clarity regarding the definition of the term "waste" vs. "product" / Inconsistent interpretation and implementation of Waste Framework Directive etc.* ** problem for reuse enterprises when e.g. used PC's are considered "waste" in that they can only be transported and treated by accredited waste collection agencies or compliance schemes.*	IT
"Make the Ecodesign Directive about ecodesign" (extend scope to other design aspects, as design for reuse, disassembly, universality, etc. and include non-energy using products)	*EuP Directive: focus on use phase of products, neglecting the potential of Design for Reuse and Recycling (D4R)*	IT
Inclusion of mandatory procurement criteria promoting purchase of reused goods in the Green Public Procurement Programme (GPP)	*GPP voluntary only*	IT
Draft EU legislation in a way that there is less flexibility for Member States on the issue of reuse	*Short-term planning by policymakers and lacking political support for reuse*	IT
Include a legal requirement to enable disassembly	*Short-term planning by policymakers and lacking political support for reuse*	IT
Accounting mechanism for B2B WEEE	*Even though trade in used B2B IT equipment is ongoing in some European countries, this is not covered by currrent WEEE Directive (2002/96/EC). reporting, with organizations collecting and treating for reuse and recycling without the same requirements defined by legislation for B2C WEEE. A solution that addresses these issues needs to be developed which considers both the drivers of the system, the value in reuse and resource exploitation, and the barriers that affect decision making. Simple annual mass data by category would be sufficient to determine an organization's total collection share from the sales figures provided by manufacturers*	IT
For B2B, regulate the disposal market to support reuse	*See above*	IT
Individual collection target for photovoltaic panels	*A collection target in the WEEE Directive of 65% of the items put on the market in the last three years is not at all realistic for PV panels (with lifetimes of about 20 yrs)*	PV

Demolition laws* and guidance / best practice for demolition	*Lacking specific legislation* **There could be targets set for reuse, to up cycle the materials generated on site. This would promote selective demolition and increase reusable materials available from projects*	C
Enforce compliance and monitoring (+ sufficient funding to provide for this)*	*Non-harmonized standards, legislation and policies* **e.g. waste management plans are not efficient, if not policed and "used"; educate contractors and show economic benefits of waste management plans*	C
Establish clearer definitions	*Lack of clarity regarding the definition of the term "waste" vs. "product" / Inconsistent interpretation and implementation of Waste Framework Directive et al. across Member States;* *This is an issue for the construction and demolition sector. Particularly the demolition sector where materials are being reused – is the materials waste or a resource. Clearer clarification, guidance and policy are required from the Environmental Agencies.*	C
Waste Framework Directive: Expand and differentiate between the main waste fractions (a) building rubble and (b) construction and demolition waste without building rubble and specify the minimum to: **Building rubble: min. 90%** **Construction and demolition waste without building rubble: min. 70%**	*Too wide scope of the goal/definition of „…construction and demolition waste … of 70 % by weight."* *C&D activities cause a lot of mixture of concrete, bricks, tiles etc. The Goal (70% reuse/recycling rate) is thus usually easy to reach without major efforts as mixture of concrete, no focus on other waste fractions and their potentials for reuse and recycling and, thus, establishing industrial networks*	C
Ecological impact assessment in policy decisions	**e.g. Banning certain substances at little contained amounts in total is not necessarily the best solution when looking at the overall environmental impacts of the product; holistic view and focus on targeting issues with the highest environmental impact*	A

Table 9: List of barriers and recommendations across ZeroWIN cases

ANNEX 2: IMPACT ASSESSMENT OF THOSE POLICY OPTIONS PRIORITIZED AT THE STAKEHOLDER WORKSHOP

HIGH-TECH / IT REUSE [ZeroWIN industrial cases 1,3, 10]	**Option 1: EU standard for 2nd-hand components & products**	**Option 2: Reuse being regarded as sector**	**Option 3: Accounting mechanism for business-to-business WEEE**	**Option 4: Strengthen reuse & recycling in green procurement**
Environmental impacts				
Potential greenhouse gas reduction *[magnitude: 0, +, ++]*	+	+	+	+
Potential increase of reuse / recycling *[magnitude: 0, +, ++]*	++	+	+	++
Potential reduction in fresh water use *[magnitude: 0, +, ++]*	+	+	+	+
Economic impacts				
Implementation costs for European Union *[magnitude: 0, +, ++]*	+	0	0	+
Implementation costs for Member States *[magnitude: 0, +, ++]*	0	+	++	+
Implementation costs for industry *[magnitude: 0, +, ++]*	+	+	+	+
Social impacts				
Effects on job creation [magnitude: 0, +, ++]	++	++	0	0
Higher public awareness on issue *[magnitude: 0, +, ++]*	0	+	0	+
General Issues				
Legislative change needed? *[Y: yes / N: no]*	Y	Y	Y	Y
Practicality *[Y: yes / N: no]*	Y	Y	?	Y
Clarity & consistency with existing EU legislation *[low, medium, high]*	Medium to high	Medium	?	L

Table 10: Short policy option impact assessment – high-tech (based on stakeholder workshop discussions)

PHOTOVOLTAICS **[ZeroWIN industrial case 2]**	**Option 1:** **EU standard for 2nd-hand components & products**	**Option 2:** **Research in reuse / recycling technologies and Guideline and best available technologies (BAT) reference documents on repair, reuse, recycling**	**Option 3:** **Enhancement of the use of standardized components**
Environmental impacts			
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	++	+	++
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	++	0 to +	++
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	+ to ++	+ to ++
Economic impacts			
Implementation costs for European Union ***[magnitude: 0, +, ++]***	+	++	+
Implementation costs for Member States ***[magnitude: 0, +, ++]***	+	+	+
Implementation costs for industry ***[magnitude: 0, +, ++]***	+ to ++	0	+ to ++
Social impacts			
Effects on job creation **[magnitude: 0, +, ++]**	++	0	+
Higher public awareness on issue ***[magnitude: 0, +, ++]***	0	+	+
General Issues			
Legislative change needed? ***[Y: yes / N: no]***	Y	N	Y
Practicality ***[Y: yes / N: no]***	Y	Y	Y
Clarity & consistency with existing EU legislation ***[low, medium, high]***	Medium to high	High	Y

Table 11: Short policy option impact assessment – photovoltaics (Based on stakeholder workshop discussions)

CONSTRUCTION [ZeroWIN industrial cases 4-8]	Option 1: EU standard for 2nd-hand components & products	Option 2: Landfill bans	Option 3: Tax incentives	Option 4: Certification systems
Environmental impacts				
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	+	0 to +	+	+
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	+	++	+	0
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	+	+	+ to ++
Economic impacts				
Implementation costs for European Union ***[magnitude: 0, +, ++]***	+	0	0	++
Implementation costs for Member States ***[magnitude: 0, +, ++]***	+	++	++	+
Implementation costs for industry ***[magnitude: 0, +, ++]***	++	+ to ++	0	+
Social impacts				
Effects on job creation **[magnitude: 0, +, ++]**	++	+	0	0
Higher public awareness on issue ***[magnitude: 0, +, ++]***	0	+ to ++	+	+
General Issues				
Legislative change needed? ***[Y: yes / N: no]***	Y	Y	N	N
Practicality ***[Y: yes / N: no]***	Y	Y	Y	N
Clarity & consistency with existing EU legislation ***[low, medium, high]***	Medium to high	Medium	Y	High

Table 12: Short policy option impact assessment – construction (Based on stakeholder workshop discussions)

AUTOMOTIVE [ZeroWIN industrial case 9]	Option 1: EU standard for 2nd-hand components & products	Option 2: Research in reuse / recycling technologies, substitution materials	Option 3: Finance pilot projects
Environmental impacts			
Potential greenhouse gas reduction ***[magnitude: 0, +, ++]***	+	+	+
Potential increase of reuse / recycling ***[magnitude: 0, +, ++]***	+	+	+
Potential reduction in fresh water use ***[magnitude: 0, +, ++]***	+	+	+
Economic impacts			
Implementation costs for European Union ***[magnitude: 0, +, ++]***	+	++	++
Implementation costs for Member States ***[magnitude: 0, +, ++]***	+	++	++
Implementation costs for industry ***[magnitude: 0, +, ++]***	++	++	0
Social impacts			
Effects on job creation **[magnitude: 0, +, ++]**	++	0	0
Higher public awareness on issue ***[magnitude: 0, +, ++]***	0	0	+
General Issues			
Legislative change needed? ***[Y: yes / N: no]***	Y	N	N
Practicality ***[Y: yes / N: no]***	Y	Y	Y
Clarity & consistency with existing EU legislation ***[low, medium, high]***	Medium to high	High	High

Table 13: Short policy option impact assessment – automotive (Based on stakeholder workshop discussions)