DISCLAIMER

This document contains key exhibits from the report *Delivering the circular economy: a toolkit for policymakers*.

The report has been produced by a team from the Ellen MacArthur Foundation, which takes full responsibility for the report’s contents and conclusions. While the key contributors and contributors listed in the acknowledgements provided significant input to the development of this report, their participation does not necessarily equate to endorsement of the report's contents or conclusions. The McKinsey Center for Business and Environment provided analytical support. NERA Economic Consulting provided support for the macroeconomic and policy analysis for Parts 2 and 3 of the report.

The report describes a methodology for circular economy policymaking. It also explores a range of policy options that Denmark – the country of the report's pilot study – could choose to pursue. The report does not recommend any specific policy intervention to Denmark or to any other country.

PROJECT FUNDER
Circular economy – an industrial system that is restorative and regenerative by design

**PRINCIPLE 1**
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
ReSOLVE levers: regenerate, virtualise, exchange

**PRINCIPLE 2**
Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
ReSOLVE levers: regenerate, share, optimise, loop

**PRINCIPLE 3**
Foster system effectiveness by revealing and designing out negative externalities
All ReSOLVE levers

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1. Hunting and fishing
2. Can take both post-harvest and post-consumer waste as an input

The ReSOLVE framework: six action areas for businesses and countries wanting to move towards the circular economy

**REGENERATE**
- Shift to renewable energy and materials
- Reclaim, retain, and restore health of ecosystems
- Return recovered biological resources to the biosphere

**SHARE**
- Share assets (e.g. cars, rooms, appliances)
- Reuse/secondhand
- Prolong life through maintenance, design for durability, upgradability, etc.

**OPTIMISE**
- Increase performance/efficiency of product
- Remove waste in production and supply chain
- Leverage big data, automation, remote sensing and steering

**LOOP**
- Remanufacture products or components
- Recycle materials
- Digest anaerobically
- Extract biochemicals from organic waste

**VIRTUALISE**
- Dematerialise directly (e.g. books, CDs, DVDs, travel)
- Dematerialise indirectly (e.g. online shopping)

**EXCHANGE**
- Replace old with advanced non-renewable materials
- Apply new technologies (e.g. 3D printing)
- Choose new product/service (e.g. multimodal transport)

### Indicative prioritisation of ReSOLVE action areas for 20 sectors in Europe

| ECONOMIC ACTIVITIES | REGENERATE |  |  |  |  |  |
|---------------------|------------|---|---|---|---|
| Information & communication services, media and telecommunications | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Scientific R&D, other professional, scientific & technical activities | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Education | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Human health and social work activities | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Administrative & support services | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Arts, entertainment and recreation | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Financial and insurance activities | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Legal & accounting head offices, consulting, architecture & engineering, TIC | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Distributive trades (incl. wholesale and retail trade) | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacture of wood and paper products, and printing | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Public administration and defence; compulsory social security | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Real estate activities | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of textiles, apparel, leather and related products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Construction | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of transport equipment | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of furniture | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Water supply, waste & remediation | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of elec. equipment, computer, electronic and optical products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of machinery and equipment | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of rubber, plastics, basic and fabricated metal products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Transportation and storage | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Agriculture, forestry and fishing | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of food, beverages and tobacco products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Mining and quarrying | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Electricity, gas, steam and air-conditioning supply | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of coke, refined petroleum, chemicals products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Manufacturing of pharmaceuticals, medicinal chemical, botanical products | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |
| Accommodation and food service activities | ![High](#) | ![Middle](#) | ![Low](#) | ![High](#) | ![Middle](#) | ![Low](#) |

Estimated potential contribution of the circular economy to economic growth, job creation and reduction of greenhouse gas emissions

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>WHOLE ECONOMY (MATERIALS AND ENERGY)</th>
<th>WHOLE ECONOMY (MATERIAL FOCUS)</th>
<th>SELECTED SECTORS (MATERIAL FOCUS)</th>
<th>GDP IMPACT</th>
<th>NET EMPLOYMENT</th>
<th>GHG EMISSION REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL: TNO</td>
<td>2030 scenario</td>
<td>N/A</td>
<td>N/A</td>
<td>3.0</td>
<td>N/A</td>
<td>70.0</td>
</tr>
<tr>
<td>EU (1): Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment</td>
<td>Full scenario</td>
<td>N/A</td>
<td>N/A</td>
<td>3.0</td>
<td>N/A</td>
<td>70.0</td>
</tr>
<tr>
<td>EU (2): Cambridge Econometrics / Biointelligence Service / EC</td>
<td>Material efficiency scenario</td>
<td>N/A</td>
<td>N/A</td>
<td>2.0</td>
<td>N/A</td>
<td>10.0</td>
</tr>
<tr>
<td>SWE: Club of Rome</td>
<td>Net job creation from increased reuse, remanufacturing, recycling, bio-refining and servitisation</td>
<td>N/A</td>
<td>N/A</td>
<td>1.4</td>
<td>N/A</td>
<td>8.0</td>
</tr>
<tr>
<td>UK: WRAP</td>
<td>Built environment</td>
<td>N/A</td>
<td>N/A</td>
<td>0.8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>FIN: SITRA</td>
<td>Forestry, pulp and paper, machinery and electronics, built environment, food waste, P2P sharing</td>
<td>N/A</td>
<td>N/A</td>
<td>0.8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>EU, built environment: TNO / EC</td>
<td>Remanufacturing industry</td>
<td>N/A</td>
<td>N/A</td>
<td>0.7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>SCO: Zero Waste Scotland</td>
<td>Waste management and recycling industry</td>
<td>N/A</td>
<td>N/A</td>
<td>0.2</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CAN: Conference Board of Canada</td>
<td>Ontario; Waste management and recycling industry: compiled from several reports, see <a href="http://ec.europa.eu/environment/circular-economy/index_en.htm">http://ec.europa.eu/environment/circular-economy/index_en.htm</a>, <a href="http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2014_env_005_waste_review_en.pdf">http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2014_env_005_waste_review_en.pdf</a></td>
<td>N/A</td>
<td>N/A</td>
<td>0.2</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>SOU: Zero Waste Europe</td>
<td>EU waste management: Zero Waste Europe; EU circular economy package: Questioning the reasons for withdrawal (2015); CAN: Conference Board of Canada, Opportunities for Ontario's Waste: Economic Impacts of Waste Diversion in North America (2014)</td>
<td>N/A</td>
<td>N/A</td>
<td>0.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1 2030 scenario
2 Full scenario; GDP impact equal to trade balance effect
3 Material efficiency scenario; GDP impact equal to trade balance effect
4 Net job creation from increased reuse, remanufacturing, recycling, bio-refining and servitisation
5 Built environment
6 Forestry, pulp and paper, machinery and electronics, built environment, food waste, P2P sharing
7 Remanufacturing industry
8 Ontario; Waste management and recycling industry

Step-by-step methodology

2.1 ALIGN ON STARTING POINT, AMBITION AND FOCUS

2.1.1 Baseline circularity level and policy landscape

2.1.2 Set ambition level

2.1.3 Select focus sectors

2.2 ASSESS SECTOR OPPORTUNITIES

2.2.1 Map circular economy opportunities in each focus sector

2.2.2 Prioritise and detail circular economy opportunities

2.2.3 Quantify sector impact

2.2.4 Identify barriers

2.2.5 Map sector-specific policy options

2.3 ANALYSE ECONOMY-WIDE IMPLICATIONS

2.3.1 Quantify economy-wide impact

2.3.2 Map economy-wide policy options

2.3.3 Prioritise, package and sequence policy options

Engage businesses and other stakeholders
Schematic overview of sector-specific impact quantification

Net value created in sector
EUR million

Net value created in deep-dive sub-sector
EUR million

Net value created per unit in deep-dive sub-sector
EUR per unit

Adoption rate %

Number of units in deep-dive sub-sector

Additional revenues and cost savings per activity
EUR per unit

Additional costs per activity
EUR per unit

Size of sector vs. deep-dive sub-sector %

Scalability factor
(between 0 and 1)

Scale up factor to full sector %

Circular scenario adoption rate, %

Business as usual scenario adoption rate, %

Additional sales

Price / value increase

Material / labour savings

Labour

Services

Materials / components

Energy

Capital

SOURCE: Ellen MacArthur Foundation
### Six policy intervention types with examples

<table>
<thead>
<tr>
<th>Policy Intervention Types</th>
<th>Examples</th>
</tr>
</thead>
</table>
| **Education, Information & Awareness** | Integration of circular economy/systems thinking into school and university curricula  
Public communication and information campaigns |
| **Collaboration Platforms** | Public-private partnerships with businesses at national, regional and city level  
Encouragement of voluntary industry collaboration platforms, encouraging value-chain and cross-sectoral initiatives and information sharing  
R&D programmes in the fields of, for example, material sciences and biosystems |
| **Business Support Schemes** | Financial support to business, for example direct subsidies, provision of capital, financial guarantees  
Technical support, advisory, training and demonstration of best practices to business |
| **Public Procurement & Infrastructure** | Public procurement  
Public investment in infrastructure |
| **Regulatory Frameworks** | Government (sector) strategy and associated targets on resource productivity and circular economy  
Product regulations, including design, extended warranties and product passports  
Waste regulations, including collection and treatment standards and targets, the definition of waste, extended producer responsibility and take-back systems  
Industry, consumer, competition and trade regulations, for example on food safety  
Accounting, reporting and financial regulations including accounting for natural capital and resources, and the fiduciary duty of investors and managers |
| **Fiscal Frameworks** | VAT or excise duty reductions for circular products and services  
Tax shift from labour to resources |
### Mapping policy interventions to barriers

<table>
<thead>
<tr>
<th>BARRIERS</th>
<th>Information &amp; awareness</th>
<th>Collaboration platforms</th>
<th>Business support schemes</th>
<th>Public procurement &amp; Infrastructure</th>
<th>Regulatory frameworks</th>
<th>Fiscal frameworks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Public communication campaigns</td>
<td>Public-private partnerships</td>
<td>Industry collaboration platforms</td>
<td>R&amp;D programmes</td>
<td>Financial support to business</td>
<td>Technical &amp; business</td>
</tr>
<tr>
<td>ECONOMICS</td>
<td>Not profitable(^1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>MARKET FAILURES</td>
<td>Externalsities</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Insufficient public goods / infrastructure(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Insufficient competition / markets</td>
<td></td>
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<tr>
<td></td>
<td>Imperfect information</td>
<td></td>
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<tr>
<td></td>
<td>Split incentives (agency problem)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Transaction costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGULATORY FAILURES</td>
<td>Inadequately defined legal frameworks</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Poorly defined targets and objectives</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Implementation and enforcement failures</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Unintended consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOCIAL FACTORS</td>
<td>Capabilities and skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Custom and habit</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. At market prices excluding the full pricing of externalities such as greenhouse gas emissions, ecosystem degradation and resource depletion.

2. Infrastructure defined as fundamental physical and organizational structures and facilities, such as transportation, communication, water and energy supplies and waste treatment.
How economy-wide circular economy policy might complement sector-specific policy

POLICY OPTIONS TO ENABLE ECONOMY-WIDE TRANSITION

CLEAR DIRECTION

REALIGNED INCENTIVES

EDUCATION AND KNOWLEDGE BUILDING

POLICY OPTIONS TO ENABLE SECTOR-SPECIFIC TRANSITIONS

SECTOR 1

SECTOR 2

SECTOR 3

SECTOR 4

1 One policy package per circular economy opportunity. For definitions of policy types, see Figure 7.

Example roadmap for packaging and implementing policy options

**SHORT TERM**
- Prepare implementation of policy packages to support 1-2 ‘quick win’ sector opportunities:
  - Conduct further consultation with businesses and other stakeholders
  - Conduct detailed policy cost-benefit and feasibility analysis
  - Gather political support for policy intervention
- Investigate which economy-wide policy options and potential sector packages could be implemented at a later stage

**MEDIUM TERM**
- Implement selected ‘quick win’ opportunities; track progress and adapt implementation as needed
- Building on momentum of ‘quick wins’, prepare implementation of (and start implementing) 2-3 economy-wide policy options and potential sector packages

**LONG TERM**
- Continue implementation, track progress and adapt implementation as needed
- Assess overall program success and determine next steps
CASE STUDY
DENMARK
### Circularity baselining in the Denmark pilot

<table>
<thead>
<tr>
<th>SCOPE</th>
<th>INDICATOR</th>
<th>DENMARK(^1)</th>
<th>EU-28(^1)</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESOURCE PRODUCTIVITY</strong></td>
<td>Resource productivity&lt;br&gt;GDP EUR / kg domestic material consumption</td>
<td>2.1</td>
<td>1.9</td>
<td>+8%</td>
</tr>
<tr>
<td><strong>CIRCULAR ACTIVITIES</strong></td>
<td>Recycling rate, excluding major mineral waste &amp; adjusted for trade(^2)&lt;br&gt;tonnes recycled/tonnes treated (percent)</td>
<td>60%</td>
<td>53%</td>
<td>+14%</td>
</tr>
<tr>
<td></td>
<td>Eco-innovation index&lt;br&gt;Index with 16 indicators (e.g. green investments, employment, patents)</td>
<td>136</td>
<td>100</td>
<td>+36%</td>
</tr>
<tr>
<td><strong>WASTE GENERATION</strong></td>
<td>Waste generated per GDP output, excluding major mineral waste&lt;br&gt;tonnes / EUR million</td>
<td>40</td>
<td>69</td>
<td>-42%</td>
</tr>
<tr>
<td></td>
<td>Municipal waste generated per capita(^3)&lt;br&gt;tonnes / capita</td>
<td>747</td>
<td>481</td>
<td>+55%</td>
</tr>
<tr>
<td><strong>ENERGY AND GREENHOUSE GAS EMISSIONS</strong></td>
<td>Share of renewable energy&lt;br&gt;Percent of gross final energy consumption</td>
<td>26%</td>
<td>14%</td>
<td>+84%</td>
</tr>
<tr>
<td></td>
<td>GHG emissions per GDP output&lt;br&gt;tonnes CO2e/ EUR million</td>
<td>225</td>
<td>343</td>
<td>-34%</td>
</tr>
</tbody>
</table>

1 2012 values if not stated otherwise  
2 Recycling of domestically generated waste (incl. exported waste, excl. imported waste)  
3 2013 data  
SOURCE: Resource Efficiency Scoreboard 2014 Highlights, European commission (2014); Eurostat; Statistics Denmark, Danish EPA
## Policy landscape in the Denmark pilot

<table>
<thead>
<tr>
<th>Policy Intervention Types</th>
<th>Examples of Existing Interventions</th>
<th>Examples of Possible Additional Interventions (as observed at start of project and not taking into account subsequent analysis)</th>
</tr>
</thead>
</table>
| **Education, Information & Awareness** | • Consumer information campaigns, e.g. ‘Use more, waste less’ and ‘Stop Wasting Food’ | • Systems thinking integrated in curricula  
• Further pilot projects to demonstrate circular economy potential to businesses |
| **Collaboration Platforms** | • Green Industrial Symbiosis programme  
• Four new partnerships (food, textile, construction and packaging) as part of the Danish Waste Prevention Strategy  
• Rethink Resources, an innovation centre to support resource efficiency in companies  
• ‘Genbyg Skive’ pilot project to re-use building materials to create business opportunities and reduce waste |  |
| **Business Support Schemes** | • Fund for Green Business Development (EUR 27m 2013–2018) to support innovation and new business models  
• Masbjerg Energy Concept (MEC) bio-refinery part funded by Innovation Fund Denmark (EUR 40m) | • Dutch ‘Green Deal’ inspired programme to provide on-demand support to companies in implementing circular economy opportunities |
| **Public Procurement & Infrastructure** | • Government Strategy on Intelligent Public Procurement contains initiatives to support circular procurement practices  
• Strategy on waste prevention also contains an initiative to develop guidelines for circular public procurement | • Guidelines on the circularity of materials and products integrated into public procurement policy |
| **Regulatory Frameworks** | • Ambitious energy efficiency and GHG emissions targets, e.g. 40% GHG reduction by 2020 vs. 20% at EU level,  
• Ambitious targets for recycling/incineration/landfill, updated every 6 years, e.g. recycle 50% of household waste by 2022  
• Taskforce for increased resource efficiency to review existing regulations affecting circular economy practices | • New metrics introduced to measure economic performance, e.g. complements to GDP such as natural capital  
• Engagement at EU level to adapt existing or introduce new regulations relevant to the circular economy, e.g. product policy |
| **Fiscal Frameworks** | • Taxes on extraction and import of raw materials, vehicle registration and water supply  
• High and incrementally increased taxes on incineration / landfill to promote recycling and waste prevention  
• Highest energy taxes in Europe (70% above EU27) and CO2 taxes  
• Tax cuts designed to promote use of low-carbon energy | • Investigation into effects of tax shift from labour to resources |

Results of sector prioritisation in Denmark pilot

NOTE: Only producing sectors (24% of national GVA) and hospitals (3.5% of national GVA) considered

SOURCE: Statistics Denmark (2011 data); Danish Business Authority; Danish Environmental Protection Agency; Ellen MacArthur Foundation

<table>
<thead>
<tr>
<th>Producing sectors</th>
<th>Prioritised sectors</th>
<th>Non-producing sector</th>
<th>Size = Gross value added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic metals and fabricated products</td>
<td>Electronic products</td>
<td>Rubber and plastic products</td>
<td>Agriculture, forestry and fishing</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>Construction</td>
<td>Electricity, gas</td>
<td>Mining and quarrying</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Machinery</td>
<td>Water supply, sewerage</td>
<td>Packaging (not sized)</td>
</tr>
</tbody>
</table>
### Short-term and long-term scenarios used in the Denmark pilot

#### Short-term (2020) vs. Long-term (2035)

<table>
<thead>
<tr>
<th>BUSINESS &amp; CONSUMER BEHAVIOUR</th>
<th>TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased acceptance of performance-based business models in businesses and the public sector, but still for niche product categories (e.g., ~10% of imaging / radiation equipment in hospitals, ~10% of machinery products)</td>
<td>• Key circular economy technologies (e.g., cascading bio-refineries, bio-based alternatives to plastics, 3D printing and design for disassembly in construction, remanufacturing techniques), existing today at late R&amp;D or early commercial stage, have been successfully piloted</td>
</tr>
<tr>
<td>• Households are comfortable using new separation systems introduced by municipalities as part of the “Denmark Without Waste” strategy (e.g., increase in collection rate of household plastic packaging waste by 15 percentage points)</td>
<td>• Key circular economy technologies existing today at R&amp;D or early commercial stage have reached maturity due to accelerated innovation</td>
</tr>
<tr>
<td>• Significant remaining margins for improvement in waste reduction</td>
<td>• Increasing remanufacturing of machinery components for use in “as new” products enabled by increasing importance of software for performance</td>
</tr>
<tr>
<td>• Rapidly increasing interest in sharing business models (e.g., shared residential and office space)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Expert interviews; DBA; Danish EPA; Ellen MacArthur Foundation.
Qualitative opportunity prioritisation of focus sectors in the Denmark pilot

QUALITATIVE ASSESSMENT OF POTENTIAL IN DENMARK PILOT

Ten circular economy opportunities in five focus sectors

1. Value capture in cascading bio-refineries
2. Reduction of avoidable food waste
3. Industrialised production and 3D printing of building modules
4. Reuse and high-value recycling of components and materials
5. Sharing and multi-purposing of buildings
6. Remanufacturing and new business models
7. Increased recycling of plastic packaging
8. Bio-based packaging where beneficial
9. Performance models in procurement
10. Waste reduction and recycling

SOURCE: Ellen MacArthur Foundation
Illustrative status of circular economy in Denmark today and potential by 2035

### FOOD AND BEVERAGE
- Near 100% of industrial organic waste valorised, but mainly in low-value applications (e.g. energy recovery, animal feed); ~3% of waste used in advanced AD, <1% cascaded bio-refining
- 80-90 kg/capita avoidable food waste p.a.

### BUILT ENVIRONMENT
- 87% of construction & demolition waste recycled yet with low quality; <1% reuse
- 10-15% materials wasted during construction
- First sharing platforms (e.g. AirBnB)

### MACHINERY
- Very high recycling rates; <1% remanufacturing
- Lifetimes already (being) optimised using e.g. predictive maintenance
- <1% performance contracts

### PLASTIC PACKAGING
- ~30% recycling (rest incinerated)
- Plastic packaging largely petro-based

### HOSPITALS
- High levels of waste
- 15-35% recycling
- Performance models only adopted for textiles

### ENERGY (NOT FOCUS IN PILOT)
- >40% renewables in electricity
- 26% renewables in final energy consumption

### DENMARK (BASED ON SECTORS ABOVE)

#### 2015
- ~75% recycling
- Bio-based materials replacing petro-based plastics in selected products
- Avoidable waste designed out
- >80% recycling (of non-toxic waste)
- 40% performance models adoption for addressable equipment

#### 2035
- >90% of organic waste in advanced AD and cascaded bio-refining
- 40-50 kg/capita avoidable food waste p.a.
- 15–35% remanufacturing
- 10–15% performance contracts

### TRANSITION ECONOMY
- Low-value circular flows (e.g. recycling, AD)
- Mix of renewable and non-renewable energy
- 15% of building materials and components reused; recycling with higher quality
- <1% waste in construction process
- Widespread building sharing

### CIRCULAR ECONOMY
- High-value circular flows (e.g. reuse, reman, cascaded value extraction for organics)
- Circular business models (e.g. sharing, leasing)
- Renewable energy

### LINEAR ECONOMY
- Linear flows (landfill, incineration)
- Efficiency; waste avoidance
- Non-renewable energy

### TRANSITION ECONOMY
- Low-value circular flows (e.g. recycling, AD)
- Mix of renewable and non-renewable energy

### CIRCULAR ECONOMY
- High-value circular flows (e.g. reuse, reman, cascaded value extraction for organics)
- Circular business models (e.g. sharing, leasing)
- Renewable energy

#### 2015
- >40% renewables in electricity
- 26% renewables in final energy consumption

#### 2035
- 100% renewables in electricity and heating
- Oil for heating and coal phased out
- Fossil fuels remain in e.g. transport

**SOURCE:** Statistics Denmark; Eurostat; Danish Climate Policy Plan; expert interviews; Ellen MacArthur Foundation
Estimated potential impact of further transitioning to the circular economy in Denmark

Economy-wide impact by 2035. Absolute and percentage change relative to the 'business as usual' scenario.

<table>
<thead>
<tr>
<th></th>
<th>GDP EUR billion (2015 prices)</th>
<th>Employment¹</th>
<th>CO₂ footprint²</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSERVATIVE</td>
<td>3.6</td>
<td>7,300</td>
<td>0.4%</td>
</tr>
<tr>
<td>AMBITIOUS</td>
<td>6.2</td>
<td>13,300</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

¹ Employment impact modelled through conversion of labour bill to job equivalents via a wage curve approach (elasticity = 0.2). Percentage change is vs. 2013 total full-time employment (Source: Statistics Denmark)

² Change in Global CO₂ emissions vs. Denmark baseline 2035 emissions; other GHG emissions are not included.

Percentage change 2035 vs. ‘business as usual’ scenario

- 0.8% GDP
- 1.4% Employment
- -0.8 Million tonnes of CO₂

- 0.6% GDP
- 1.4% Employment
- -2.3 Million tonnes of CO₂

- 0.4% GDP
- 0.6% Employment
- -2.5 Million tonnes of CO₂

- 0.8% GDP
- 0.6% Employment
- -6.9 Million tonnes of CO₂

SOURCE: Ellen MacArthur Foundation; NERA Economic Consulting
Breakdown of potential economic impact by quantified opportunity

<table>
<thead>
<tr>
<th>CIRCULAR ECONOMY OPPORTUNITY</th>
<th>ESTIMATED ANNUAL VALUE CREATED BY 2035¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrialised production and 3D printing of building modules</td>
<td>33%</td>
</tr>
<tr>
<td>Value capture in cascading bio-refineries</td>
<td>17%</td>
</tr>
<tr>
<td>Remanufacturing and new business models²</td>
<td>17%</td>
</tr>
<tr>
<td>Sharing and multi-purposing of buildings</td>
<td>16%</td>
</tr>
<tr>
<td>Reuse and high-value recycling of components and materials</td>
<td>7%</td>
</tr>
<tr>
<td>Reduction of avoidable food waste</td>
<td>7%</td>
</tr>
<tr>
<td>Performance models in procurement</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

¹ Average between conservative and ambitious scenario. This sector-specific impact does not include indirect effects, e.g. on supply chains, that are captured in the economy-wide CGE modelling.

² Including scaling from machinery sector (including pumps, wind turbines and other machinery products) to adjacent manufacturing sectors (electronic products, basic metals and fabricated products, other manufacturing, mining and quarrying)

SOURCE: Ellen MacArthur Foundation
### Barrier matrix for the ten prioritised opportunities in Denmark

<table>
<thead>
<tr>
<th>BARRIERS</th>
<th>CIRCULAR ECONOMY OPPORTUNITIES</th>
<th>ECONOMICS</th>
<th>MARKET FAILURES</th>
<th>REGULATORY FAILURES</th>
<th>SOCIAL FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value capture in cascading bio-refineries</td>
<td>Reduction of avoidable food waste</td>
<td>Industrialised production and 3D printing of building modules</td>
<td>Reuse and high value recycling of components and materials</td>
<td>Sharing and multi-purposing of buildings</td>
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<tr>
<td>Not profitable for businesses—even if other barriers are overcome</td>
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<tr>
<td>Capital intensive and/or uncertain payback times</td>
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<tr>
<td>Technology not yet fully available at scale</td>
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<tr>
<td>Externalities (true costs) not fully reflected in market prices</td>
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<tr>
<td>Insufficient public goods / infrastructure provided by the market or the state</td>
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<tr>
<td>Insufficient competition / markets leading to lower quantity and higher prices than is socially desirable</td>
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<td>Imperfect information that negatively affects market decisions, such as asymmetric information</td>
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<td>Split incentives (agency problem) when two parties to a transaction have different goals</td>
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<tr>
<td>Transaction costs such as the costs of finding and bargaining with customers or suppliers</td>
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<tr>
<td>Inadequately defined legal frameworks that govern areas such as the use of new technologies</td>
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<tr>
<td>Poorly defined targets and objectives which provide either insufficient or skewed direction to industry</td>
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<tr>
<td>Implementation and enforcement failures leading to the effects of regulations being diluted or altered</td>
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<tr>
<td>Unintended consequences of existing regulations that hamper circular practices</td>
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<tr>
<td>Capabilities and skills lacking either in-house or in the market at reasonable cost</td>
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<tr>
<td>Custom and habit ingrained patterns of behaviour by consumers and businesses</td>
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</tbody>
</table>

1. At market prices excluding the full pricing of externalities such as greenhouse gas emissions, ecosystem degradation and resource depletion
2. Infrastructure defined as fundamental physical and organisational structures and facilities, such as transportation, communication, water and energy supplies and waste treatment
Prioritisation of policy options – ‘Value capture in cascading bio-refineries’

- Form public private partnerships to finance the deployment of mature bio-refining technologies
- Provide low-cost loans or loan guarantees for the deployment of mature bio-refining technologies
- Incorporate bio-refining into the government’s long-term strategic plans
- Stimulate the development of advanced, high-value bio-refining technologies by funding cross-institutional R&D clusters
- Reduce VAT on high value chemicals derived from waste feedstock
- Require municipalities to collect organic waste separately
- Propose a minimum proportion of 2nd generation biofuels in the EU biofuel target
- Provide a business advice service
- Identify and communicate necessary changes to EU policy (or its national implementation) to address unintended consequence
- Require municipalities to send organic waste for one round of processing to extract high value compounds before it could be incinerated / used as fertiliser

SOURCE: Ellen MacArthur Foundation; NERA Economic Consulting