Energy and the Sustainable Development Goals

1. No poverty
   - End poverty in all its forms everywhere

2. Zero hunger
   - End hunger, achieve food security and improved nutrition and promote sustainable agriculture

3. Good health and well-being
   - Ensure healthy lives and promote well-being for all at all ages

4. Quality education
   - Ensure inclusive and quality education for all and promote lifelong learning

5. Gender equality
   - Achieve gender equality and empower all women and girls

6. Clean water and sanitation
   - Ensure access to water and sanitation for all

7. Affordable and clean energy
   - Ensure access to affordable, reliable, sustainable and modern energy for all

8. Decent work and economic growth
   - Promote inclusive and sustainable economic growth, employment and decent work for all

9. Industry, innovation and infrastructure
   - Build resilient infrastructure, promote sustainable industrialization and foster innovation

10. Reduced inequalities
    - Reduce inequality within and among countries

11. Sustainable cities and communities
    - Make cities and human settlements inclusive, safe, resilient and sustainable

12. Responsible consumption and production
    - Ensure sustainable consumption and production patterns

13. Climate action
    - Take urgent action to combat climate change and its impacts

14. Life below water
    - Conserve and sustainably use the oceans, seas and marine resources

15. Life on land
    - Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss

16. Peace, justice and strong institutions
    - Promote just, peaceful and inclusive societies

17. Partnerships for the goals
    - Revitalize the global partnership for sustainable development
A historical review of Nuclear and Sustainable Development

CSD – 9 (2001)

- Exhaustive debate
- Agreement to disagree on nuclear’s role in sustainable development
- Agreement that the “choice of nuclear energy rests with countries”

WSSD (2002)

- JPOI: a series of actions promoting clean and affordable energy (renewable energy, efficiency improvements, advanced energy technologies)
- Nuclear power is an advanced energy technology

Source: Leila Mead, IISD
Nuclear compares favourably across many sustainability indicators

<table>
<thead>
<tr>
<th>Economic</th>
<th>Levelised cost of electricity generation</th>
<th>Overnight investment cost*</th>
<th>Security of energy supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle GHG emissions</td>
<td>Acidification potential</td>
<td>Eutrophication potential</td>
<td>Abiotic resource depletion potential</td>
</tr>
<tr>
<td>Solid waste</td>
<td>Radioactive waste**</td>
<td>Water use***</td>
<td>Land use</td>
</tr>
<tr>
<td>Impact on human health</td>
<td>Employment</td>
<td>Fatality rates along supply chain</td>
<td></td>
</tr>
</tbody>
</table>

* Sensitive to geographical location for solar, wind and hydro technologies
** Closed fuel cycle in fast reactors reduce the volume of HLW and radiotoxicity per unit of electricity generated
*** Dry cooling system eliminates water needs for cooling in thermo-electric power plants

Source: Derived from IAEA
Nuclear power has low potential for abiotic resource depletion

- ARD potential: depletion of fossil fuel + mineral (e.g. iron, copper, nickel, rare earth metals, uranium)

Source: Derived from Ecoinvent
.. low acidification potential

Source: Derived from Ecoinvent
.. but high water requirements for cooling

- In case of water scarcity, alternatives exist for inland NPPs
  - Wet recirculating towers, dry cooling.
  - Advanced reactors including SMRs - higher efficiencies less cooling waters withdrawn

*Water withdrawals across fuel cycles*

Source: Derived from NREL and Fthenakis and Kim (2010)
..low volumes of waste due to high density of uranium

- Around 80% of all nuclear waste has already been sent for safe disposal
- Only 2% - 3% of radioactive waste is HLW – challenges in terms of radiotoxicity and long half-life
  
  ⇒ Consensus on disposal in stable geological formations + multiple engineering barriers
  ⇒ First deep geological repositories to be expected within a decade (Finland, Sweden)
  ⇒ Spent Nuclear Fuel as a resource? Subject to reprocessing, retrievability

- Future technologies can significantly reduce the volume and half-life of HLW

<table>
<thead>
<tr>
<th></th>
<th>Once-through fuel cycle</th>
<th>Closed nuclear fuel cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLW (Plutonium+ Americium+ Curium) (kg/TW państw)</td>
<td>27.9</td>
<td>0.15</td>
</tr>
<tr>
<td>Time for radiotoxicity to reach the level of uranium ore</td>
<td>Several hundred thousand years</td>
<td>Several centuries</td>
</tr>
</tbody>
</table>

Source: Derived from IAEA
.. low human health impacts

- Natural exposure to ionising radiation is several magnitudes higher than artificial

  ⇒ Natural – 2420 μSv, Medical – 620 μSv, Nuclear fuel cycle – 0.2 μSv

Source: Derived from UNSCEAR, Treyer et al. (2014)
.. thus low external costs

- Environmental and health damage cost not reflected in the price of electricity

Average external costs in the EU

External costs (Euro cents/kW·h)

- Offshore wind
- Nuclear
- Ocean
- CSP
- NGCC—CCS
- NGCC
- PV
- Lignite—CCS (oxy-fuel)
- Lignite
- Coal—CCS (oxy-fuel)
- Lignite—CCS (post-combustion)
- Coal
- Coal—CCS (post-combustion)
- Biomass

- Health impacts
- Biodiversity
- Crop yield losses
- Material damage

Source: Derived from NEDS
Nuclear power contributes to economic growth and new employment

- Nuclear, CSP and small hydro provide comparable number of jobs per MWe of installed capacity

<table>
<thead>
<tr>
<th>Technology</th>
<th>Jobs/MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>1.06</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0.5038</td>
</tr>
<tr>
<td>CSP</td>
<td>0.47</td>
</tr>
<tr>
<td>Micro Hydro &lt; 20 MW</td>
<td>0.45</td>
</tr>
<tr>
<td>Hydro &gt; 20 MW</td>
<td>0.19</td>
</tr>
<tr>
<td>Coal</td>
<td>0.1866</td>
</tr>
<tr>
<td>Hydro &gt; 500 MW</td>
<td>0.1137</td>
</tr>
<tr>
<td>Hydro Pumped Storage</td>
<td>0.0954</td>
</tr>
<tr>
<td>Combined Cycle</td>
<td>0.0544</td>
</tr>
<tr>
<td>Wind</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Source: Harker and Hirschboeck, 2010

...there are also indirect jobs

⇒ In USA, for every 100 direct jobs in nuclear plant, 726 indirect and induced jobs are created in the rest of economy

- In comparison to its alternatives, more skilled labour is necessary to design and operate nuclear technologies

⇒ High potential to generate economic value
Nuclear power and sustainable development

- Is nuclear power consistent with SD?
  - Nuclear power compares favourably to alternatives with respect to SDGs attainment

- Today’s advantages
  - Low GHG emissions, enhanced energy security, stable and predictable generation costs, internalisation of most externalities, small and managed volumes of waste, ample resources, small land footprint, small impact on ecosystems and human health

- Today’s concerns
  - Disposal of HLW, safety and non-proliferation, public perceptions → acceptability

- Technology subject to change: closed fuel cycles
  - Reduced needs for uranium, less HLW and shorter radiotoxicity

- One Size Does Not Fit All
  - Identify trade-offs, set priorities in a national context

⇒ More in the forthcoming report
Adequate resources

- Supplies are plentiful and resources are well diversified
- Small fuel volumes
- Possibility to accumulate significant stockpiles

⇒ Nuclear power contributes to enhanced energy security

Source: Derived from OECD NEA IAEA