Exeter Energy, Environment and Economy (4E)

Constrained areas renewable energy planning and their end-of-life waste legacy

*Intelligent Community Electricity Lifecycle Technology Impact Calculator (**iCELTIC** tool)*

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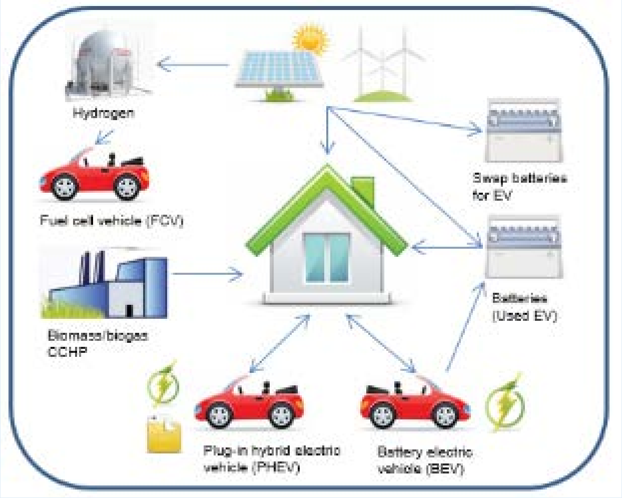
Project ICE: Intelligent Community Energy



LCA of intelligent energy systems for remote or isolated communities

- Development of an LCA tool to assess and compare different future energy system scenarios
- Selecting appropriate sustainability indicators by working with local communities (through, e.g., workshops or surveys)
- Co-design of a multi-criteria decision analysis (MCDA) tool with the local communities to rank different options

Challenges for Local Energy Systems

- The transition to sustainable energy requires strategic planning involving:
  - Technical
  - Environmental
  - Socioeconomic

  characteristics of the energy technologies involved → **RENEWABLES ARE NOT ALL THE SAME!**
- Challenges for a constrained local energy systems:
  - Generation options are restricted
  - Decisions about infrastructure development have to be context-specific
  - Generic supports for low carbon energy technologies is not adequate
- Additional challenge of integrating a life cycle perspective into the planning:
  - Expertise
  - More time
  - More funds

Case study

- Constrained electricity system of Ushant island in France
- Seven scenarios for a shift to a fossil fuel free local electricity grid
- Carefully designed mixes of:
  - Wind
  - Solar
  - Tidal energy

ICE project case study Ushant

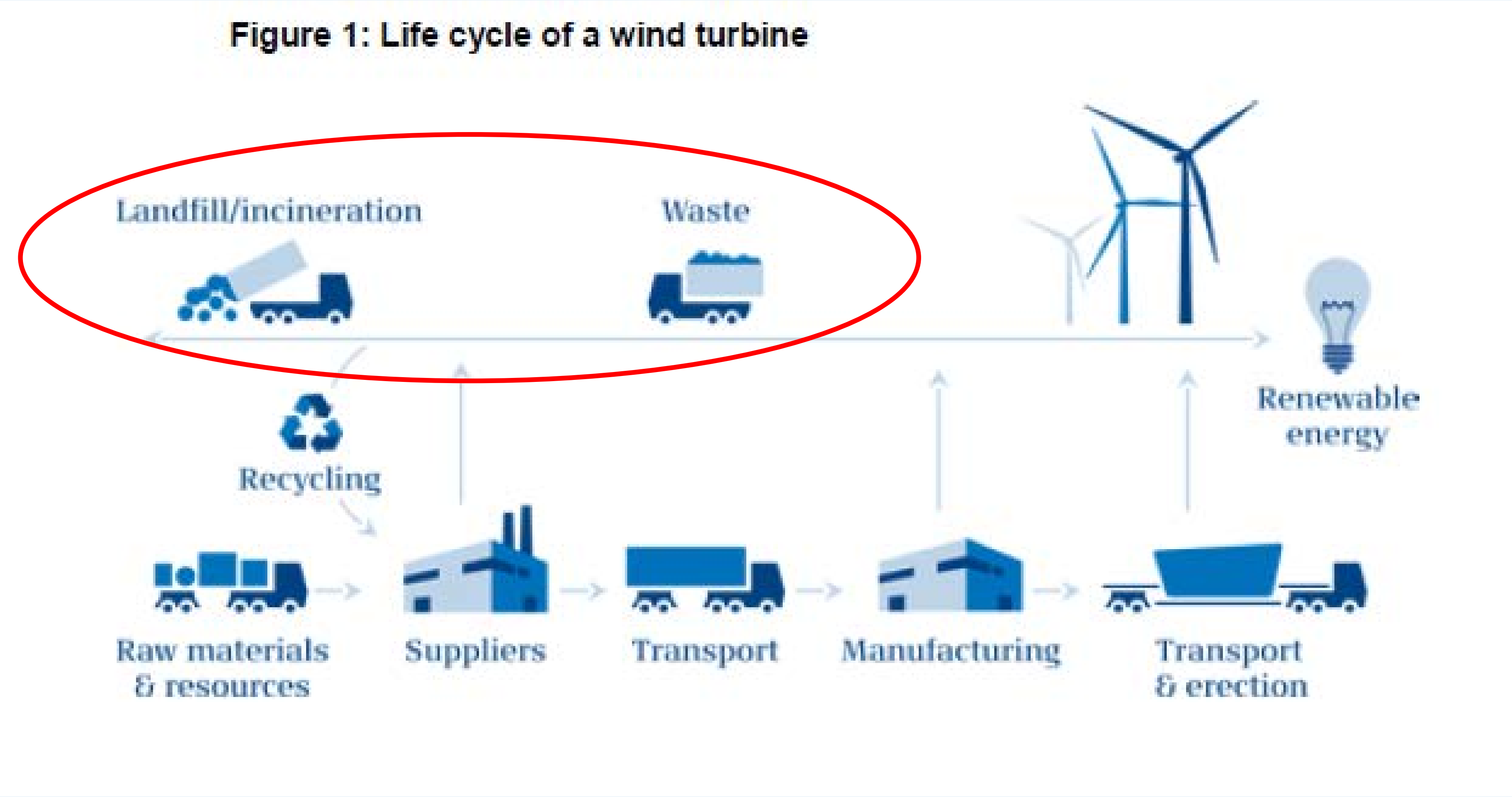
We used this tool to assess the seven scenarios developed within ICE project for the island of Ushant in France for which the **annual electricity generation demand** has been set to **6808 MWh**.
Based on the method and the input data we acquired the results illustrated in the graph that follows.

Scenario	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Electricity generated (MWh)	489	4400	5600	1189	4600	2189	5400
Wind 300 kW	300						
Wind 800 kW		800					800
Wind 2MW			2000				
Tidal turbine 1MW				1000	1000	2000	1000
Photovoltaic roof mounted 3kWp	189	3600	3600	189	3600	189	3600

Why do we need an Intelligent Community Electricity Lifecycle Technology Impact Calculator (iCELTIC) ?

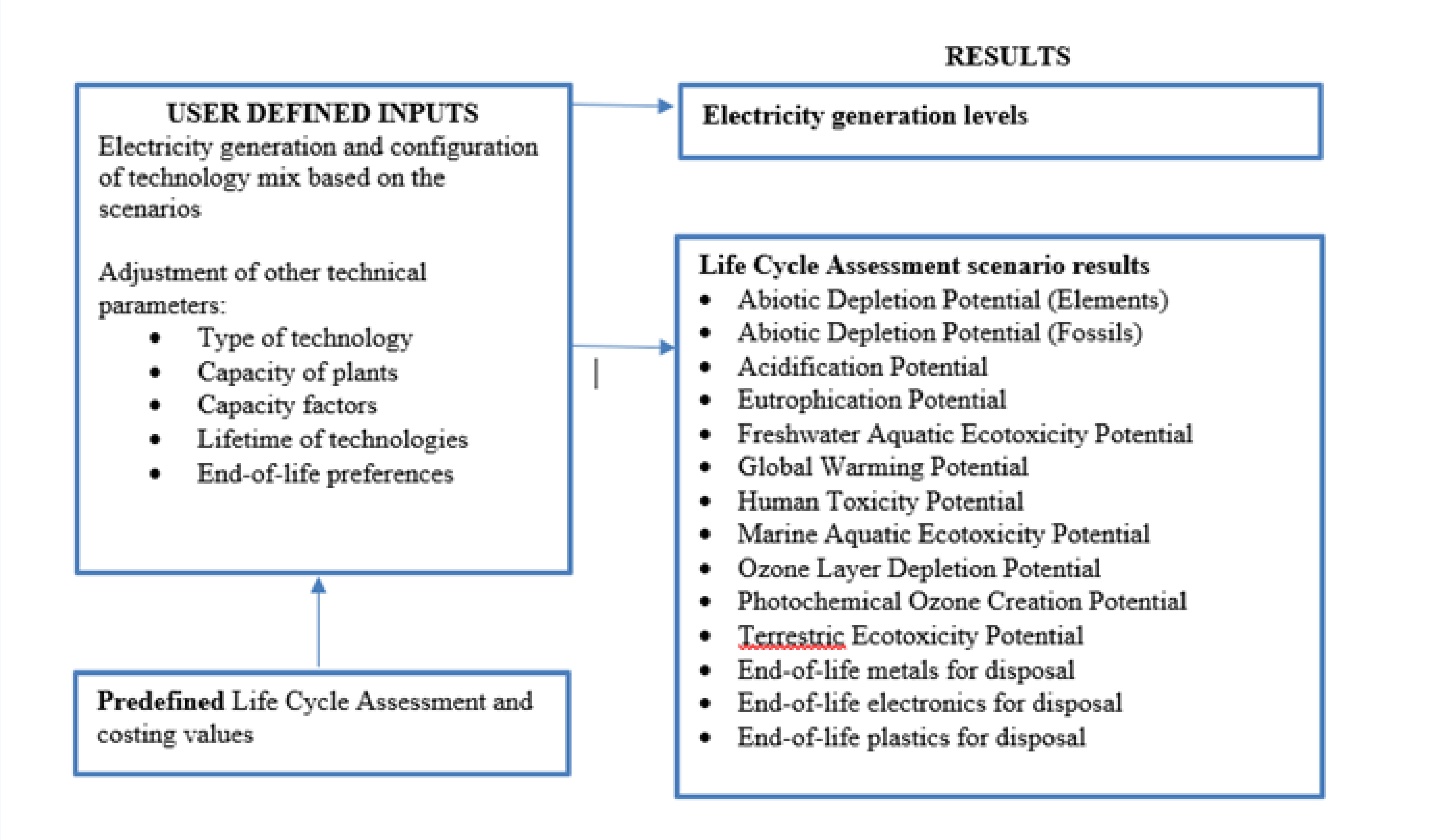
- **Climate emergency** requires decarbonisation of the existing electricity provision
- Constrained areas are easier to manage such as small islands that depend on diesel generators
- Choosing the right mix should not jeopardise the arising of other environmental impacts
- Avoiding burden shifting to:
  - other areas (e.g. where the manufacturing of the infrastructure components happens)
  - Next generations arising of environmental impacts from waste at the end of life of the renewable energy components
- Life cycle assessment (LCA) methodology approach looks into whole life cycle of electricity generation (overlooked end-of-life)
- Other models exist but:
  - Focus on changing the share of renewables in the total electricity generation mix as a whole missing areas not connected to the grid
  - Do not specify technology, capacity and generation demand on local scale
  - Do not cover local stakeholders (LCAs need time and money)
  - Too sophisticated for local stakeholders
  - Do not answer the question:
  - What could be the impacts of adding two wind turbines of 2MW capacity in a specific site where they are expected to have a 20% capacity factor

Life Cycle Analysis



https://www.vestas.com/~/media/vestas/about/sustainability/pdfs/lca_v112_study_report_2011.pdf

iCELTIC inputs and outputs



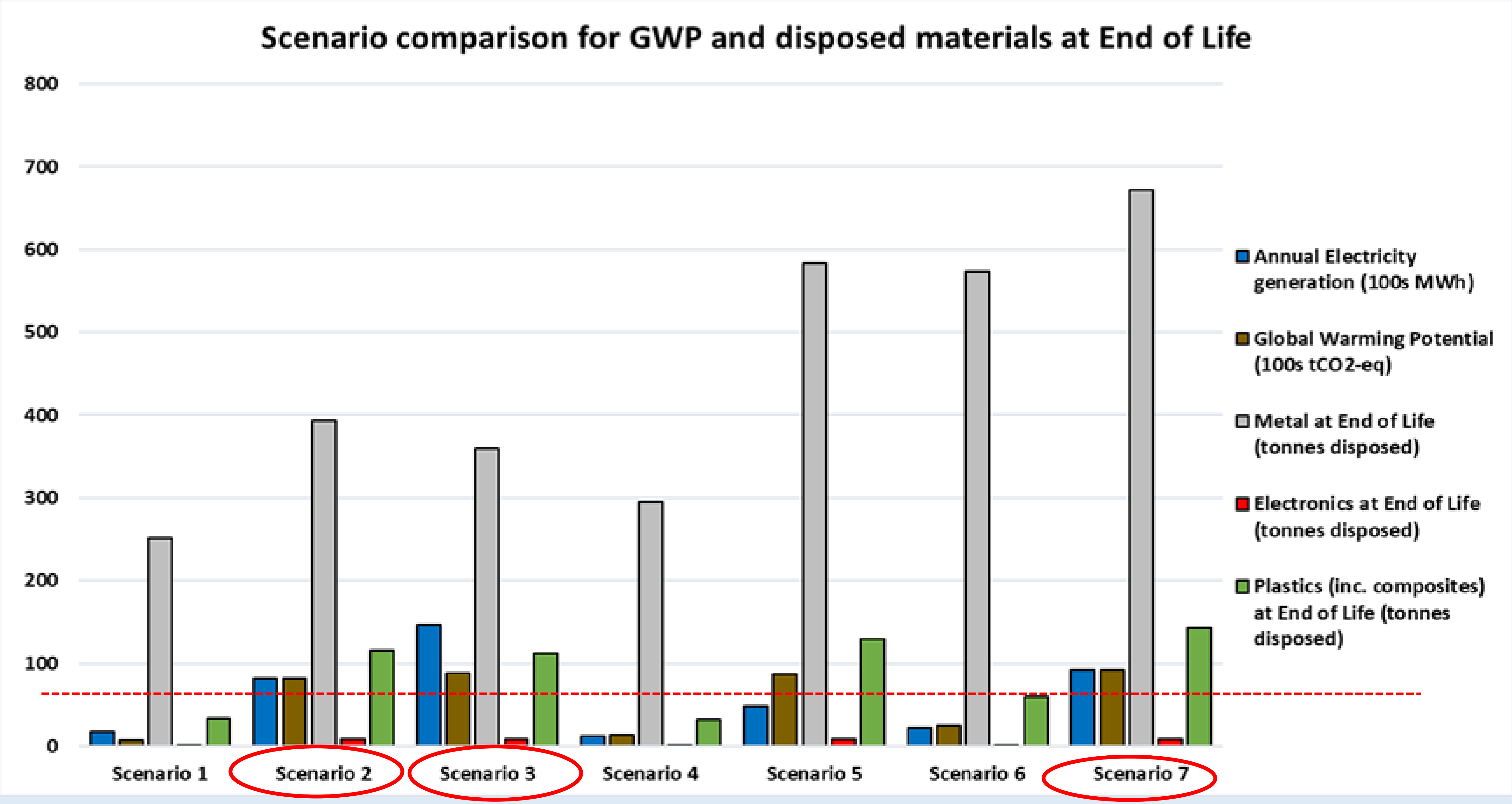
iCELTIC inputs and data

The users defines:

- electricity generation in MWh per annum
- the names of the plants/installations (e.g. Wind farm name 1)
- other technical parameters such as the type of technology (e.g. 300 kW wind turbine)
- the capacity (e.g. 600 kW)
- the capacity factor (e.g. 20%)

The tool contains:

- predefined values for the LCA impact indicators per kW based on results of LCA models
- Material composition of technologies per device (e.g. for 1MW Tidal Generator 400ts steel, 120 ts of)
- technologies covered :
  - onshore wind of 300kW, 800kW and 2MW capacity
  - multi-Si roof mounted photovoltaic of 3kWp
  - tidal turbine of 1 MW


Scenario comparison for GWP and disposed materials at End of Life
800
700
600
500
400
300
200
100
0
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Annual Electricity generation (100s MWh)
Global Warming Potential (100s tCO2-eq)
Metal at End of Life (tonnes disposed)
Electronics at End of Life (tonnes disposed)
Plastics (inc. composites) at End of Life (tonnes disposed)

Closing…

- **Graph only indicative** results for the annual electricity generation, global warming potential and aggregated number of metals, electronics and plastics (incl. composites) disposed at the end of life.
- **More updated results available** both numerical and graphical in the following publication:

“Sustainable energy planning for remote islands and the waste legacy from renewable energy infrastructure deployment” Journal of Cleaner Production

- **Only three scenarios** (2,3 and 7) satisfy the annual electricity generation requirements
- **All scenarios decarbonize** the mix **BUT:**
    - Different electricity production levels
    - Different material disposal profiles
    - Challenges and trade-offs when configuring an optimum renewable energy mix

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Questions?

Thank you