POTENTIALS AND IMPACTS OF SELECTED NEGATIVE EMISSION TECHNOLOGIES IN LIGHT OF GREEN PROCESS ENGINEERING

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ABSTRACT

Climate models show that negative emission technologies (NETs) are required to achieve the temperature increase limits set in the Paris Agreement. NETs remove and store carbon away from the atmosphere. Various NETs have been proposed in the literature, and their potential capacities, benefits, limitations, impacts, and costs are continuously being established. Green process engineering (GPE) promotes sustainability, pollution reduction, and human health risk minimization. NETs implementation must follow the principles of green engineering. This paper aims to evaluate the features of selected NETs in light of green process engineering. It was found that all the NETs have both positive and negative impacts on the Green Engineering (GE) principles. It is recommended to integrate the GE principles during the planning and large-scale implementation of NETs for sustainability.

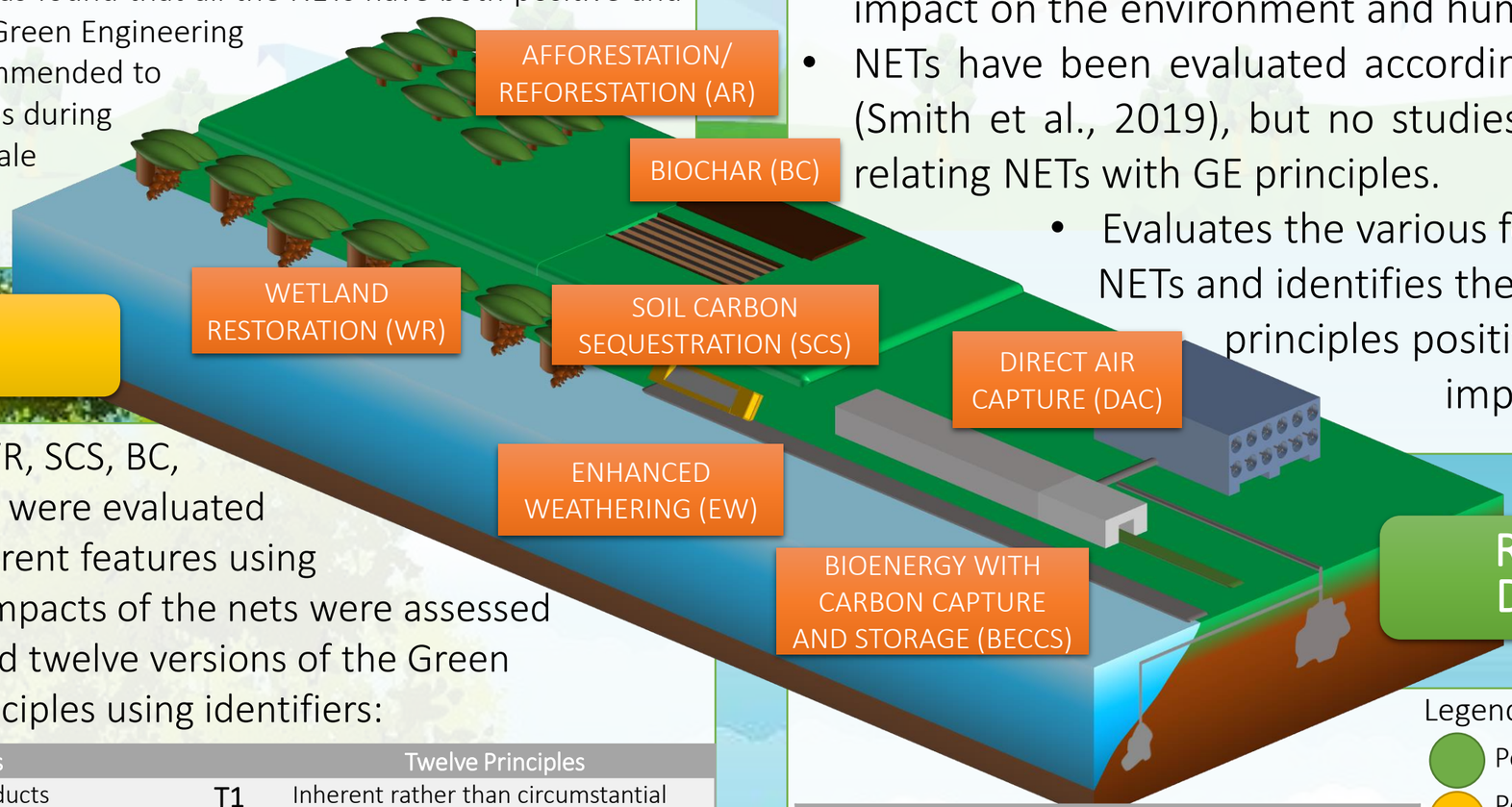
INTRODUCTION

- IPCC climate models show that negative emission technologies (NETs) are needed to limit global warming (Smith et al., 2016)
- NETs sequester carbon from the atmosphere and store it in the soil, underground, etc. (McLaren, 2012)
- Green process engineering (GPE) emphasizes sustainable technological designs that minimizes impact on the environment and human health
- NETs have been evaluated according to the UN SDGs (Smith et al., 2019), but no studies have been found relating NETs with GE principles.
  - Evaluates the various features of selected NETs and identifies the green engineering principles positively and negatively impacted by each NET.

METHODOLOGY

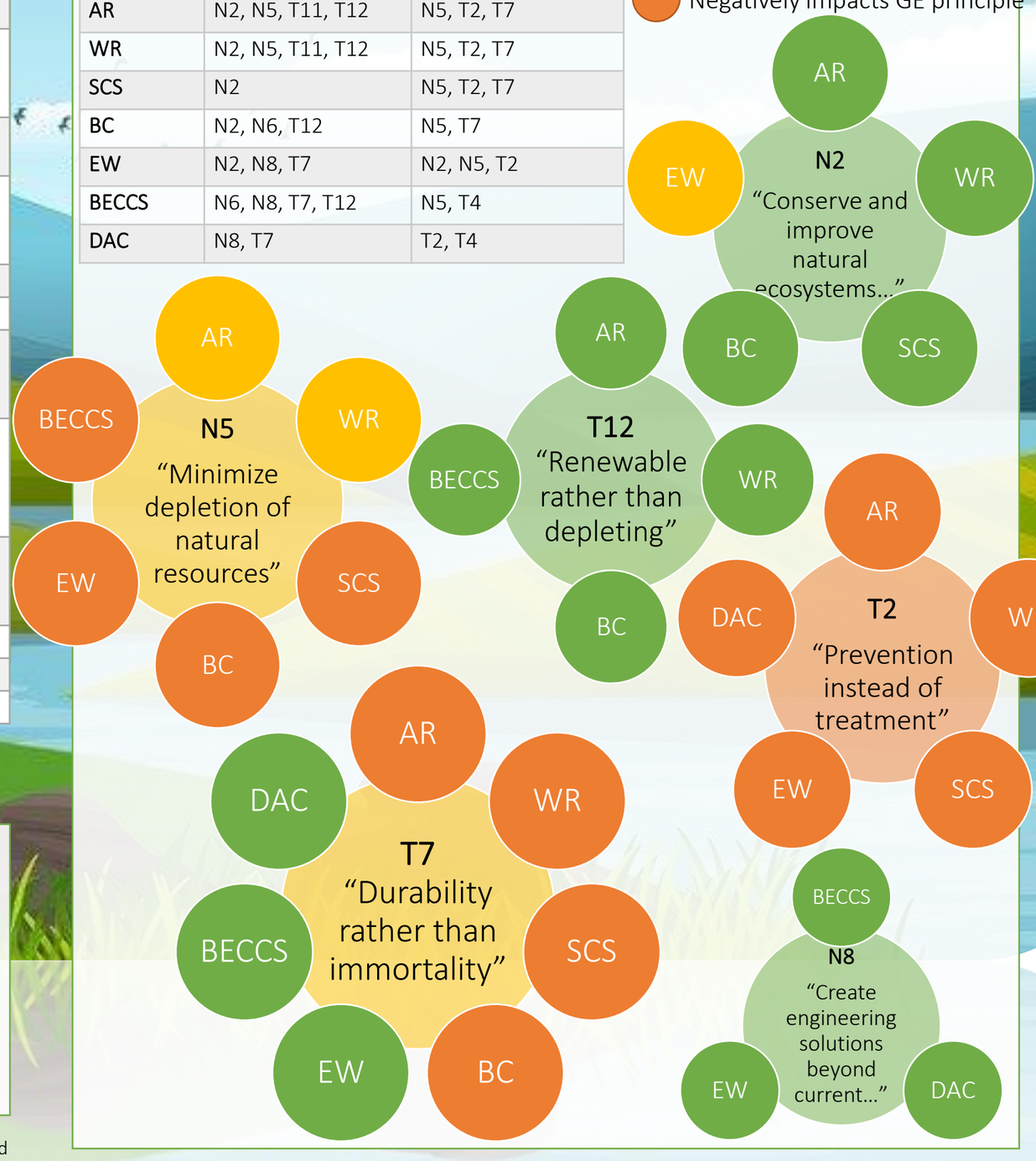
Selected NETs (AR, WR, SCS, BC, EW, BECCS, and DAC) were evaluated in terms of their different features using literature data. The impacts of the nets were assessed based on the nine and twelve versions of the Green Engineering (GE) Principles using identifiers:

Nine Principles		Twelve Principles	
N1	Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.	T1	Inherent rather than circumstantial
N2	Conserve and improve natural ecosystems while protecting human health and well-being.	T2	Prevention instead of treatment
N3	Use life-cycle thinking in all engineering activities.	T3	Design for separation
N4	Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.	T4	Maximize efficiency
N5	Minimize depletion of natural resources.	T5	Output-pulled versus input-pushed
N6	Strive to prevent waste.	T6	Conserve complexity
N7	Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.	T7	Durability rather than immortality
N8	Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.	T8	Meet need, minimize excess
N9	Actively engage communities and stakeholders in development of engineering solutions	T9	Minimize material diversity
		T10	Integrate material and energy flows
		T11	Design for commercial “afterlife"
		T12	Renewable rather than depleting



RESULTS AND DISCUSSIONS

NETs	Positively Impacted GE Principles	Negatively Impacted GE Principles
AR	N2, N5, T11, T12	N5, T2, T7
WR	N2, N5, T11, T12	N5, T2, T7
SCS	N2	N5, T2, T7
BC	N2, N6, T12	N5, T7
EW	N2, N8, T7	N2, N5, T2
BECCS	N6, N8, T7, T12	N5, T4
DAC	N8, T7	T2, T4



CONCLUSIONS

- All the NETs have both positive and negative impacts on the GE principles.
- AR, WR, SCS, BC, and EW positively impact principle N2. EW also negatively impacts N2.
- Almost all NETs negatively impact principle N5.
- It is recommended to integrate the GE principles during the planning and large-scale implementation of NETs for sustainability.

References: McLaren, D. (2012). A comparative global assessment of potential negative emissions technologies. Process Safety and Environmental Protection, 90(6), 489–500.

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