ChE-413: Chemical Engineering Product Design

Exercise set 2

Instructions: Prepare your responses to each of the below questions in the form of a PDF document (not handwritten!). Make sure your name is clearly visible on the document and the pages are numbered. Upload your completed document on the course Moodle no later than one week after the lecture (i.e. by 30th September 2024, 23:59). Each student must upload their own work.

Question 2.1: Cigarette Butts

Tabacco does not only have a negative impact on the health of individuals consuming it but also threatens the health of the environment. More than 750,000 metric tons of cigarette butts are estimated to make their way into the environment every year. Cigarette and e-cigarette waste pollute water, air, and soil with residual nicotine, toxic chemicals, and heavy metals. Additionally, cigarette filters, commonly made out of cellulose acetate, take more than 10 years to decompose, meaning cigarette butts will stay around as unsightly litter for a long time.

Imagine you are part of a team including members of the local government and product development engineers from an environmental organization and your team is asked to develop a solution to this problem. During this process, you have already gathered many ideas in the first brainstorming step. With this many ideas suggested, 30 of which are listed in the table below, it is now your task to sort and categorize these ideas.

1.	Biodegradable (natural or synthetic) cigarettes that degrade faster than normal cigarettes
2.	Make cigarettes that do not contain toxic substances
3.	Cigarettes that can be eaten by birds
4.	Build a special car with a brush in the front bumper to clean the cigarettes
5.	Have a deposit system for cigarette butts
6.	Destroy the cigarettes with radiation
7.	Cigarettes that make a sound when thrown on the ground (social pressure)
8.	Make a license for cigarette smokers which proves that they know how to dispose of them
9.	Cigarettes that are edible after smoking
10.	Reward people that collect a lot of cigarette butts and return them
11.	Create cigarettes that are slowly decomposed by air
12.	Cigarette buds that degrade with UV light
13.	Have cigarette trash cans everywhere
14.	Only sell filter-free pipes and tobacco
15.	Make cigarettes really disgusting so no one buys them
16.	Make cleaning cigarette butts in the public a civil service task
17.	Expensive fines for those who do not dispose of the cigarette butts correctly
18.	Mandatory license to buy/smoke cigarettes
19.	Create shops that would pay to bring back finished cigarettes
20.	Have tracking chips in every cigarette butt to make it possible to find them
21.	Add a reminder on the packaging to not throw cigarettes into nature

22.	Use robots to clean the cigarette butts
23.	Flammable cigarettes that could be burnt easily once they are thrown on the streets
24.	Develop bacteria that are present everywhere and can decompose cigarettes
25.	Employ people whose only job is cleaning away cigarettes
26.	Reusable cigarettes
27.	Ban cigarettes
28.	Increase the price of cigarettes (e.g. by high taxes)
29.	Prison sentence for throwing away cigarettes
30.	Make cigarettes without filters

Question 2.2: Decaffeination of Coffee Beans

After fossil crude oil, coffee is the second-most traded commodity in the world. The rise of the general popularity of coffee started in the early 20th century when coffee consumption first surged as the industry's technology advanced and the availability of the products increased. A second wave of increase in popularity came in the 70s, when, through popular coffee brands and franchises, coffee started to be seen more as an experience than just as a commodity. In the early 2000s, which marked the beginning of today's specialty coffee culture, an even greater interest in complex, lighter roast coffees, single-origin coffee beans, and general techniques of coffee preparation in general. With the increase in popularity of coffee not just for its caffeine content, but also just as a potentially delicious beverage, there is also an increase in the popularity of decaffeinated coffee.

Imagine you are hired by a specialty coffee roastery that wants to expand its product portfolio to include craft decaffeinated coffee. They are interested in finding the most promising method for decaffeination of their artisan coffee beans, mainly having a customer base in mind that is interested in the highest quality, locally-roasted coffees. For this, you are considering four methods for coffee decaffeination listed below.

(1)	Ethyl acetate method
(2)	Swiss water method
(3)	Supercritical CO_2 method
(4)	Methylene chloride method

In order to assess which method would be the best for producing decaffeinated coffee for a small local company, your team decided to use the matrix selection technique to assess these ideas. **Propose the criteria and weighting factors (<u>with justification for the criteria and weighting</u>) for the matrix. Then perform the matrix analysis (justification for the scoring is <u>not required</u>). Finally, based on your matrix analysis, give a conclusion about which method is the most promising.**

Question 2.3: The Future of the Automobile Industry?

The automotive industry is constantly evolving. While change is mostly driven by the pure search for innovation and competition, it is often pushed in certain directions by new regulations and laws dictated by governing bodies. One of such regulations that the industry will have to adapt to in the next decades is the unavoidable shift away from fossil-fuel-powered cars, due to their inherent impact on climate change due to carbon dioxide emissions. While the last few years have mainly seen one alternative being pushed into the center of attention – electric vehicles – there are of course other options that are regularly discussed. Two of them, which are considered due to the limited change needed to the already peak-engineered engines used today, are 1) Electrofuels (e-fuels), which are a class of synthetic fuels manufactured using captured carbon dioxide (or carbon monoxide), together with hydrogen obtained from electrolytic water splitting, and 2) bio fuels (e.g. Biodiesel), which are derived from biological sources like vegetable oils, animal fats, or recycled greases.

Imagine the European Union is discussing the question of which fuel system should be prioritized for the future. Next to cars powered by fossil fuel-based gasoline (petrol) as the benchmark technology they are considering e-fuels, biomass-derived fuels, and lithium-ion battery powered electric cars. You, as a consultant employed by the European Commission, have been tasked to assess which of these three emerging technologies is most promising for wide and rapid implementation to replace standard fossil fuel-powered cars. For this purpose, the matrix selection technique is used. The head of the ministry and his top advisors have agreed on the following criteria and weighting factors for the assessment.

Criteria	Weighting Factor
Energy Efficiency	0.20
Energy source accessibility/scalability	0.25
Sustainability	0.15
Technology maturity	0.05
Maintenance cost	0.05
System lifetime	0.10
Safety	0.20

Compare the three suggested technologies amongst each other and with the benchmark technology. <u>The justifications for your scores are required as written explanations</u>. Then give a conclusion about which of the technologies is best suited for the future large-scale application.