ChE/EID447: Sustainability and Pollution Prevention
Prof. Davis

Spring 2020 Project 1: How sustainable is this entity/company/industry?
Project Proposals due Tuesday, February 25th (3 ideas, 1 page, E-mail)
First Draft due Friday, March 27th (submit hard copy in class)
Final draft due Friday, April 17th (submit hard copy in class, E-mail *.pdf)

To be sustainable, an organization (a company or a group of people authorized to act as a single entity) should employ practices that improve the welfare of society and have minimal environmental impact. To evaluate these practices, one can assess the societal and environmental impact of the organization quantitatively through their activities, policies, emissions and wastes, impact of products, installations, etc. Here are some of the many reasons why organizations assess or should assess their sustainability:

1. It is good marketing to provide society with sustainability data; people often prefer products of environmentally and socially friendly organizations.
2. Sustainability is a goal of many local and national governments and these organizations must account for their practices.
3. Improving environmental performance often improves the economic performance of a company by making the various stages of production more efficient.
4. A sustainability report provides guidance towards new strategic decisions and improvements.
5. A sustainability report shows compliance with existing environmental and labor laws and regulations.

For this project, choose an organization and the industry that this organization is in and collect as much data as possible to evaluate the sustainability of its operations. It can be anything, but if you don't have a strong preference, we suggest companies related to agriculture, transportation or shared mobility, or power generation / distribution. Following the model given in class (with three primary indicators HUMS, ECOS, and WEALTH for for-profit companies), outline all the steps necessary for this evaluation by writing a "Model Description" section of your report following these guidelines:

A. Choose at least 18 (more is better) basic indicators you will use to evaluate the secondary indicators AIR, LAND, WATER, PR(WEALTH), ST(WEALTH), RE(WEALTH), POLIC, HEALTH, and KNOW. If you choose a not-for-profit organization, you can use fewer secondary indicators for WEALTH. Give your reasons (one paragraph) for choosing each basic indicator and its units of measure; remember that intensive indicators are better for comparison. Each indicator must be normalized with <u>thoroughly justified</u> target values (ideally in a table). Include all the data you gather for each indicator as an appendix.
B. For each PRIMARY indicator (ECOS, HUMS, and WEALTH), outline the steps necessary for calculating the fuzzy and crisp values for ONE of its BASIC indicators, including giving the data you used and its source, the relevant normalizing curve, the normalized value in the most recent year as an example, the relevant membership functions, the fuzzy value, and any other information necessary for someone to repeat your analysis. Use the WMS linguistic variable with a medium peak value of 0.7 (not 0.6) for basic indicators. You may also make your own linguistic variable if you like, but be sure to justify your choice.
C. Show all work necessary to calculate the fuzzy and crisp values of ONE secondary indicator from the fuzzy values of its basic indicators as an example. <u>Make sure to show the rule base</u>, membership function, and all equations and numbers you use. For all other secondary indicators, just give the rule base you used. Give the membership functions for the secondary indicators only if they differ from the example. Give the fuzzy and crisp values for all secondary indicators. Note that you do not use the

crisp values of the indicators for calculating primary indicator values, this is just outlining how it is done.

D. Show all work necessary to find the fuzzy and crisp value for each primary indicator (ECOS, HUMS, and WEALTH) from the values of the secondary indicators; <u>be sure to give and justify the relevant rule bases and membership functions.</u>

E. Give the fuzzy and crisp values for OSUS. Use this result to comment on the sustainability of your chosen corporation relative to other companies in its industry.

This is a group assignment; each group should create their own model and submit one report. The project will be graded according to the following four categories equally:

1. Report quality (25%) – A good report should include the following sections: Abstract (one page or so <u>with a picture of your model</u>), Introduction (1-2 pages), Model Description (as many pages as it takes to do A. through E. above), Results (comment on the output of your model and give context/output for the industry, 2-3 pages), Appendices (raw data, normalized data, normalization curves, rule bases) and References. A poorly edited or formatted report will receive less credit than a well-formatted or well-edited one. You are REQUIRED to take your report to the writing center before you submit it – they will send me an E-mail when you do. <u>You will get no credit for this category if you do not take your report to the writing center.</u>

2. Data quality (25%) – How much data did you collect and on how many companies? How many years back did you go? Did you cite sources for the data correctly? How appropriate / convincing / realistic is the data? How many indicators did you use? (Remember, more is better.) Was there any data you should have been able to find but did not?

3. Model quality (25%) – Is the model "complex enough" to evaluate sustainability accurately? How well did you justify the indicators you chose? Do the indicators seem very interrelated, or do they seem to cover a wide range of impacts? **Do you have a clear diagram/picture of your model in the abstract and introduction?** Are the rule bases you chose clearly displayed? **Are your normalization curves and rule bases thoughtfully justified with sources?** Remember that the model is only as good as the knowledge behind it and that knowledge must be backed up with sources or justification.

4. Derivations (25%) – Are the example calculations correct and well presented? Did you use Mathtype/TeX to make the equations pretty? Did you show calculations for 3 basic, 1 secondary, and 3 primary indicators? Is enough work shown that it is clear what the author is doing? Are enough details given that the analysis could be repeated?

The attached list of corporate sustainability (basic) indicators is indicative of the areas you should be researching but not necessarily complete; you can use any of these indicators according to what is suitable for the corporation or industry you are modeling. You can and should use indicators of your own, as long as you justify your choice of indicator in your report. Remember that <u>good indicators are INTENSIVE, not extensive</u> and should scale well with the size of the company. As an example, a good indicator for greenhouse gas emissions might have units of tons of CO_2 equivalents emitted indirectly and directly per ton of product produced, rather than just tons of CO_2 emitted directly. Another example is to use "market share" or "revenue produced per employee" rather than market capitalization or revenue, respectively.

AIR

- Greenhouse gas (GHG) emissions (production and product use/disposal) – remember that emissions can be direct or indirect
- NO_x, SO_x, or CO emissions
- VOC (volatile organic compounds) emissions
- CFC (chlorofluorocarbons) emissions
- TSP (total suspended particulates) emissions

- renewable energy use
- fossil fuel use
- percentage of environmentally friendly buildings, i.e., buildings with passive solar design, economy fixtures, automatic switches, faucets that turn off when not used, etc.

LAND

- solid and liquid waste generation (production and product use/disposal)
- amount of solid and liquid waste treated/recycled
- nuclear waste generated
- reforested land
- land restored by the company
- amount of material dumped/recycled
- total land use per unit of production

WATER

- water treatment/recycling
- BOD (biological oxygen demand)
- COD (chemical oxygen demand)
- hydrocarbon effluents
- wastewater emissions
- total water use per unit of production

POLIC

- compliance with international human rights and environmental agreements
- compliance with national environmental laws/regulations
- compliance with national labor laws/regulations
- benefits to employees
- percentage of employees covered by bargaining agreements
- nondiscrimination policies
- avoidance of child labor
- respect of rights of indigenous people expressed by numbers of violations of such rights
- financial and other contributions to communities
- Ideas for other POLIC indicators: https://www.warren.senate.gov/newsroom/press-releases/warren-introduces-accountable-capitalism-act

HEALTH

- injury rates
- fatality rates
- lost days
- occupational health problems
- health insurance coverage of employees

KNOW

- R&D expenditures

- percentage of employees receiving training in new technologies and methods, ethics, anti-corruption policies, etc.
- interaction with institutions of higher learning
- education programs or sponsorships
- percentage of employees with high school, college, graduate degrees
- donations to schools or educational charities

PR(WEALTH)

- production/operating costs
- change in financial assistance received from government
- taxes paid to government
- debt ratio

ST(WEALTH)

- net revenue per employee
- operating income or gross profit per employee
- market capitalization (stock price times number of total shares) or market share
- P/E ratio of stock
- total current assets
- cash on hand

RE(WEALTH)

- new capital investments
- new products introduced
- dividends or stock buyback plans

Other resources which may be useful:

Ideas for indicators based on planetary boundaries:
https://backend.orbit.dtu.dk/ws/portalfiles/portal/129908498/Bj_rn_et_al._2016a_Word_with_DOI.pdf

GRI – List of sustainability reports: http://www.globalreporting.org/Home
Fortune 500 companies: http://money.cnn.com/magazines/fortune/fortune500/2010/
WBCSD – examples of indicators: http://www.wbcsd.org/
AIChE – Sustainability Index for chemical companies: http://www.aiche.org/ifs/sustainability/about.aspx
One Report: Integrated Reporting for a Sustainable Strategy by Eccles and Krzus (2010)
Sustainable Development in the Process Industries: Cases and Impact by Harmsen and Powell (2010)
     (I have both these books in my office if you want to look at them.)