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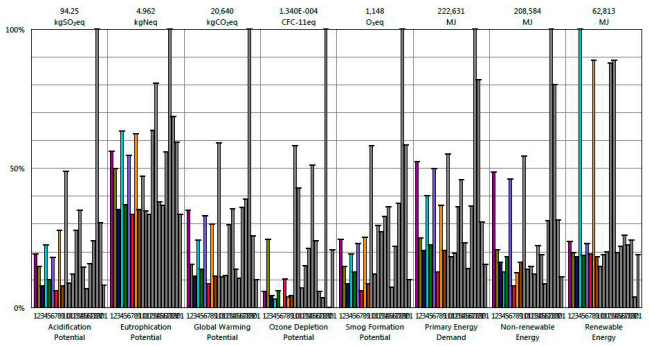
Design Problem

As climate change continues to be an ever-growing concern, embodied energy has become increasingly prevalent. Access to life-cycle inventory data of leading life-cycle tool applications are provided in-house at the discretion of the inventors aren't transparent enough. This proposal focuses on BIM-based tool Tally created in conjunction with Autodesk, Thinkstep, and GaBi. The goal is to solve the question: What is the whole-building life-cycle analysis tool Tally not doing and how can it be improved? There is a common problem tools developed by individual organizations have. The tools that these companies develop are considered to work well in their controlled environment but often lack the flexibility to be accepted within and outside of the architecture, engineering, and construction industry. Autodesk Revit's Tally, a whole-building life-cycle assessment tool, is a methodology for comparing the relative environmental impacts of materials and processes. Although the interoperability between Tally and Revit is a step forward, this methodology doesn't make any claims as to the appropriateness of materials used for common decision-making selection by the users and the impact category results can be quite obscure when comparing many options during the design process. The problem is that Tally gives the user too many options and its graphic charts are difficult to understand and filter which design option is best. This proposal aims to investigate an easier way to inform robust decision-making based on a multitude of possible design options that Revit's parametric model produces through the plug-in Tally. Additionally, Dynamo along with the plug in Bumblebee and Design Explorer can be used as a platform to achieve this objective. There are there some impact categories (global warming, acidification potential, and ozone depletion potential) that are more pertinent than others depending on design stage, geographical location, rating system requirements. In this study, the goal is to suggest a methodology to optimize building life-cycle performance by exploring alternatives in cladding material of a simple building unit based on the parameters of impact categories that include: global warming, acidification, ozone depletion, eutrophication, smog formation, renewable energy, non-renewable energy, primary energy, and mass of the building.

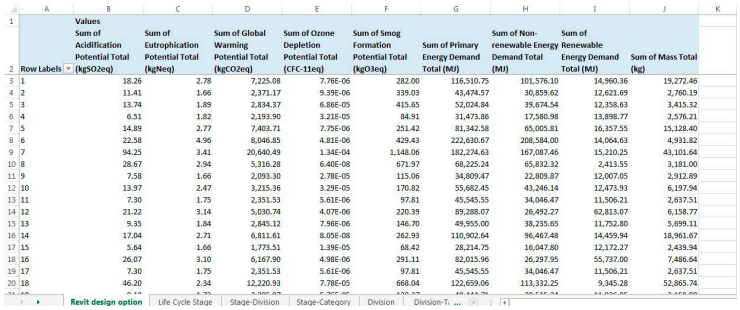
Analytical Approach

The case study buildings were modeled in Revit and have different input parameters for each cladding material element for each design option. Outputs pulled from the Revit models are all represented in the results using a medium of charts and graphs that compare design options in Tally's report in the form of PDF and Excel. From this, streamlined analysis was used for life-cycle impact assessment using Dynamo, Bumblebee, and Design Explorer. This will allow users to benefit from connections to building data and create further transparency of impact results for decision-making and give design options for the client quickly. The study suggests guidelines for an integrated decision-making paradigm that utilizes the capabilities of BIM within the domains of Dynamo, Bumblebee and Design Explorer. Bumblebee is an Excel and Dynamo interoperability plugin that helped improve Dynamo's ability to read and write Tally's Excel file during this process. Bumblebee was able to read Tally's excel document narrowed down to a specific range called "Revit Design Option" and transposed this to a data.csv file to import into Design Explorer. Dynamo was able to create new lists that were organized and succinct complimented with Python, which was used to collect all of the images of the Revit buildings that were manually screenshot. Design Explorer made Tally's results measurable and designers can now qualify a design according to their specific project performance criteria. Design Explorer allowed users visualize and filter groups of impact category assessment options based on a set of design options. I was able to export the Dynamo script in the form of a data.csv file and a series of images of models. After all of the data was generated, it was hosted on the web using Google Drive. Design Explorer read the data.csv file and generated a parallel coordinates plot visualization of the Dynamo script. The plot's vertical axes represent design variables based on material and performance metrics (impact results) and the lines running horizontally across the plot represent design options. Users can investigate design options by clicking on a thumbnail and reviewing a full size image of Revit's model.

Flowchart



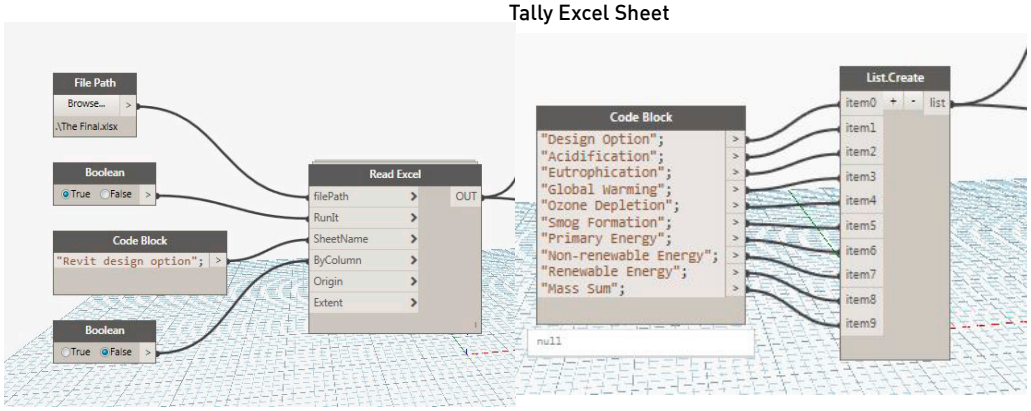
Tally Report



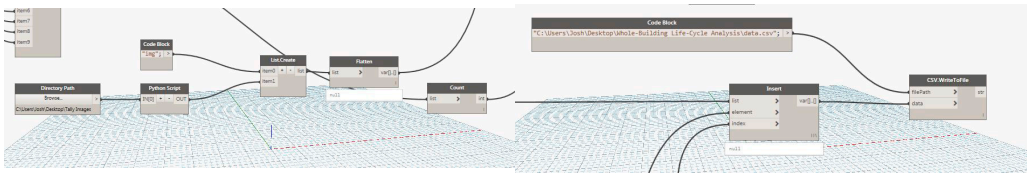
Row Labels	Values Sum of Acidification Potential Total (kgSO2eq)	Sum of Eutrophication Potential Total (kgNeq)	Sum of Global Warming Potential Total (kgCO2eq)	Sum of Ozone Depletion Potential Total (CFC-11eq)	Sum of Smog Formation Potential Total (kgO3eq)	Sum of Primary Energy Demand Total (MJ)	Sum of Non-renewable Energy Demand Total (MJ)	Sum of Renewable Energy Demand Total (MJ)	Sum of Mass Total (kg)
1	18.26	2.78	7,225.08	7.76E-06	282.00	116,510.75	101,576.10	14,960.36	19,272.46
2	11.41	1.66	2,371.17	9.39E-06	339.03	43,474.57	30,859.62	12,621.69	2,760.19
3	13.74	1.89	2,834.37	6.86E-05	415.65	52,024.84	39,674.54	12,358.63	3,415.32
4	6.51	1.82	2,193.90	3.21E-05	84.91	31,473.86	17,580.98	13,898.77	2,576.21
5	14.89	2.77	7,403.71	7.75E-06	251.42	81,342.58	65,005.81	16,357.55	15,128.40
6	22.58	4.96	8,046.85	4.81E-06	429.43	222,630.67	208,584.00	14,064.63	4,931.82
7	94.25	3.41	20,640.49	1.34E-04	1,148.06	182,274.63	167,087.46	15,210.25	43,101.64
8	28.67	2.94	5,316.28	6.40E-08	671.97	68,225.24	65,832.32	2,413.55	3,181.00
9	7.58	1.66	2,093.30	2.78E-05	115.06	34,809.47	22,809.87	12,007.05	2,912.89
10	13.97	2.47	3,215.36	3.29E-05	170.82	55,682.45	43,246.14	12,473.93	6,197.94
11	7.30	1.75	2,351.53	5.61E-06	97.81	45,545.55	34,046.47	11,506.21	2,637.51
12	21.22	3.14	5,030.74	4.07E-06	220.39	89,288.07	26,492.27	62,813.07	6,158.77
13	9.35	1.84	2,845.12	7.96E-06	146.70	49,955.00	38,235.65	11,752.80	5,699.11
14	17.04	2.71	6,811.61	8.05E-08	262.93	110,902.64	96,467.48	14,459.94	18,961.67
15	5.64	1.66	1,773.51	1.39E-05	68.42	28,214.75	16,047.80	12,172.27	2,439.94
16	26.07	3.10	6,167.90	4.98E-06	291.11	82,015.96	26,297.95	55,737.00	7,486.64
17	7.30	1.75	2,351.53	5.61E-06	97.81	45,545.55	34,046.47	11,506.21	2,637.51
18	46.20	2.34	12,220.93	7.78E-05	668.04	122,659.06	113,332.25	9,345.28	52,865.74

Revit design option | Life Cycle Stage | Stage-Division | Stage-Category | Division | Division-T...

Tally Excel Sheet



Dynamo Lists and Bumblebee Read Excel

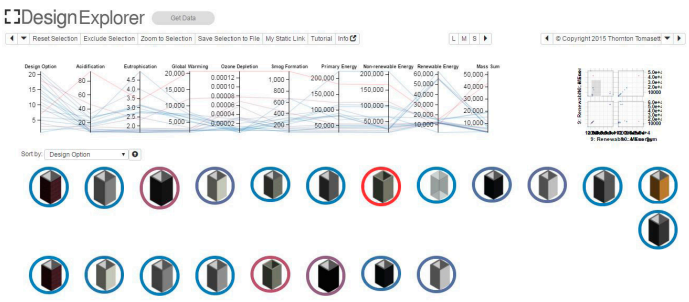


Python for Images

Dynamo export to data.csv

Design Op	Acidificati	Eutrophic	Global Wa	Ozone De	Smog For	Primary Er	Non-rene	Renewabl	Mass Sum
1	18.25543	2.782943	7225.077	7.76E-06	282	116510.7	101576.1	14960.36	19272.46
2	11.40578	1.66381	2371.171	9.39E-06	339.0269	43474.57	30859.62	12621.69	2760.188
3	13.7361	1.886469	2834.365	6.86E-05	415.6534	52024.84	39674.54	12358.63	3415.324
4	6.511765	1.816796	2193.902	3.21E-05	84.90895	31473.86	17580.98	13898.77	2576.211
5	14.88549	2.770116	7403.707	7.75E-06	251.4164	81342.58	65005.81	16357.55	15128.4
6	22.58428	4.962159	8046.853	4.81E-06	429.4312	222630.7	208584	14064.63	4931.823
7	94.25261	3.405093	20640.49	0.000134	1148.062	182274.6	167087.5	15210.25	43101.64
8	28.66891	2.942285	5316.282	6.40E-08	671.9725	68225.24	65832.32	2413.55	3181
9	7.578294	1.661561	2093.296	2.78E-05	115.0636	34809.47	22809.87	12007.05	2912.892
10	13.97046	2.473358	3215.36	3.29E-05	170.8206	55682.45	43246.14	12473.93	6197.943
11	7.295489	1.748517	2351.53	5.61E-06	97.81014	45545.55	34046.47	11506.21	2637.512
12	21.22102	3.140899	5030.741	4.07E-06	220.3928	89288.07	26492.27	62813.07	6158.771
13	9.354589	1.840182	2845.121	7.96E-06	146.6959	49955	38235.65	11752.8	5699.115
14	17.04185	2.713069	6811.615	8.05E-08	262.9251	110902.6	96467.48	14459.94	18961.67
15	5.643882	1.655384	1773.508	1.39E-05	68.42493	28214.75	16047.8	12172.27	2439.936
16	26.06866	3.097245	6167.903	4.98E-06	291.1054	82015.96	26297.95	55737	7486.644
17	7.295489	1.748517	2351.53	5.61E-06	97.81014	45545.55	34046.47	11506.21	2637.512
18	46.19833	2.336648	12220.93	7.78E-05	668.0375	122659.1	113332.2	9345.281	52865.74
19	8.183185	1.726838	2285.966	5.76E-05	138.3718	40444.71	28515.24	11936.85	3158.998
20	26.16461	3.15614	6121.188	2.01E-05	313.5832	80488.73	25324.4	55184.28	7701.779
21	32.92007	3.994261	7329.668	2.85E-05	376.4363	102363.5	46625.12	55788.8	11053.72

Exported data.csv file



Design Explorer Link:

http://tt-acm.github.io/DesignExplorer/?GFOLDER=0B3_FLVcUDiIKbkF5cnc1Z2JvUG8