Münster: Energy and Greenhouse Gas Balance

1990 — 2021

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Content:

1 Introduction.

2.Methods:

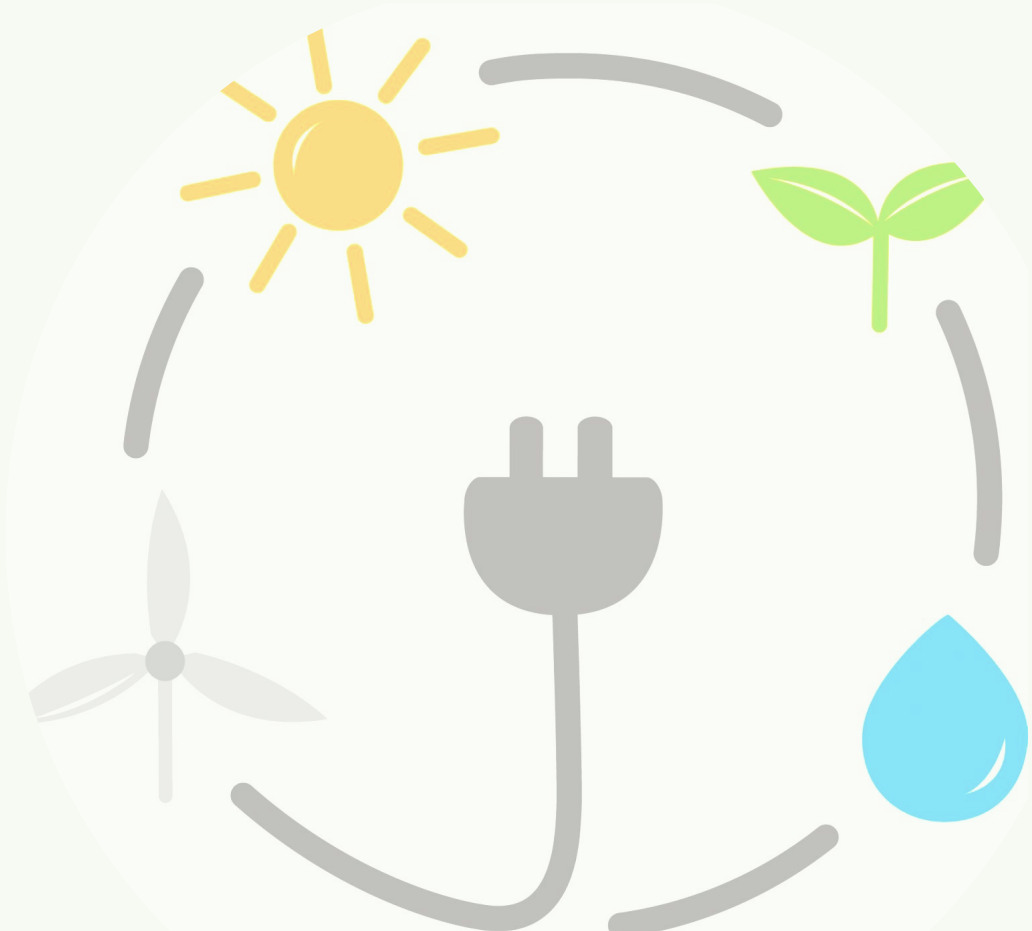
2.1 Importing python libraries and the datasets.

2.2 Processing.

2.3 Integration.

3. Results.

4. Conclusion.



1. Introduction:

MÜNSTER, GERMANY'S CLIMATE PROTECTION CAPITAL.

CITY'S ENERGY CONSUMPTION AND RELATED GREENHOUSE GAS EMISSIONS.

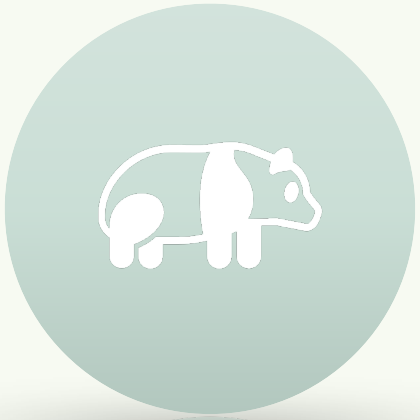
THE RENEWABLE ENERGY PRODUCTION TRENDS OVER TIME.

USING PUBLICLY AVAILABLE DATASETS AND PYTHON PROGRAMMING LANGUAGE.

The Question:

"How can Münster enhance its sustainable urban development strategies, focusing on reducing CO2 emissions and reinforcing renewable energy production?"

2. Methods:



2.1. LOADING THE DATASETS INTO PANDAS DATAFRAME.

2.2. PROCESSING

2.3. INTEGRATION

2.3 Integration:

Tables (3)
- co2_emissions_table
- renewable_energy_table
- co2_emissions_energy_source_table

	year	Private house...	Trade and oth...	Industry	Transport	Heat	Electricity	Total_co2	Total as of 1990
1	1990	817146.28049578...	846374.36551813...	293939.74398608...	660748.80622557...	1120972.59	836487.8	4575669.5862255...	0
2	1995	774039.74596263...	801725.97552234...	278433.678515023	649866.50056141...	1055941.1840000...	798258.21599999...	4358265.30056142	-0.047513108533...
3	2000	773328.01672684...	800988.78880958...	278177.65885936...	638984.19489726...	1058947.6323957...	793546.83199999...	4343973.1236888...	-0.050636624470...
4	2005	806450.63961849...	835296.15776341...	290092.36192454...	628101.88923310...	961406.12267234...	970433.03663411...	4491780.2078460...	-0.018333792857...
5	2010	684161.37554975...	735889.94088020...	185496.82865309...	622684.73143002...	788078.26957102...	817469.87551203...	3833781.0215961...	-0.162137704799...
6	2015	636894.09897666...	629441.403926151	217637.18325246...	596134.94608171...	744600.73993956...	739371.94621571...	3564080.3183922...	-0.221080051513...
7	2016	607277.94790935...	632025.21120086...	214250.89899473...	598972.70368360...	755325.94559757...	698228.11250738...	3506080.8198935...	-0.233755682349...
8	2017	578793.98479325...	623804.37954298...	215604.50510163...	593667.54891031...	768608.30783904...	649594.56159883...	3430073.2877860...	-0.250366919387...
9	2018	588419.94997515...	592654.296510337	232468.64192687...	588925.58884212...	777881.83129194...	635661.05712042...	3416011.3656668...	-0.253440113781...
10	2019	533848.63623419...	549176.92623865...	225833.35841584...	582527.29960925...	707314.74879157...	601544.17209711...	3200245.1413866...	-0.300595228505...
11	2020	521173.26771446...	512646.28562178...	204680.18804485...	571041.01028308...	718326.22104706...	520173.520334033	3048040.4930452...	-0.333859135672...
12	2021	510254.30425752...	549104.26879818...	191003.12248186...	565862.33512017...	713612.22215789...	536749.47337967...	3066585.7261953...	-0.329806125987...

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	year	Photovoltaic	Wind power	Hydropower	Biogas plants ...	Sewage / land...	Biomethane i...	Total RE in ele...	Solar thermal	Heat pumps	Pellets	Firewood	Biogas plants ...	Sewage / land...	Biomethane i...	Total RE in heat	Total RE prod...
1	1990	0	63.2	239.8	0	0	0	303	24.84	42.96875	0	0	0	0	0	67.80875	370.80875000000...
2	1995	28.0112	63.2	239.8	0	0	0	331.01120000000...	349.14	195.3125	0	0	0	0	0	544.4525	875.4637
3	2000	482.53883999999...	63.2	239.8	0	11850	0	12635.53884	1052.42	347.65625	12.5	0	0	15000	0	17212.57625	29848.11509
4	2005	2637.63906	21804	239.8	0	11850	0	36531.43906000000...	4110.66	500	487.5	495	1237.7	15000	0	21830.86	58362.29906000000...
5	2010	16953.45818	22815.2	436	16417.4	11850	0	68472.05817999999...	8827.3	8277.5	2712.5	2370	14649.42	15000	0	51836.72	120308.77818
6	2015	36430.8288	34406.88	436	44952.2	12290.2	14816	143331.3088	10670.86	14890	3812.5	3810	37828.736	7570.27	21963	100544.566	243875.8748
7	2016	37358.187300000...	34456.64	436	44952.2	15708.24	23218	156129.2673	10944.818	15617	3950	4033.8	37828.736	10762.24	31864	115000.594	271129.8613
8	2017	39083.184400000...	55059.84	436	44952.2	15414.22	12059	167004.4444	11078.678	16492	4075	4078.8	37828.736	8370.43	19457	101380.644	268385.8884
9	2018	42910.861259999...	60545.6	436	44952.2	15617.32	20490	184951.18125999...	11217.598	17531.5	4212.5	4168.2	37828.736	8043.99	26793	109795.52399999_	294746.70525999...
10	2019	47745.490560000...	60545.6	436	44952.2	15617.32	17479	186775.61056	11396.998	18731.5	4275	4641.9	37828.736	7740	22673	107287.13399999...	294062.74456
11	2020	53857.6	60545.6	436	44952.2	15617.32	18767	194175.72	11652.298	19969	4437.5	4641.9	37828.736	7740	23153	109422.43400000...	303598.154

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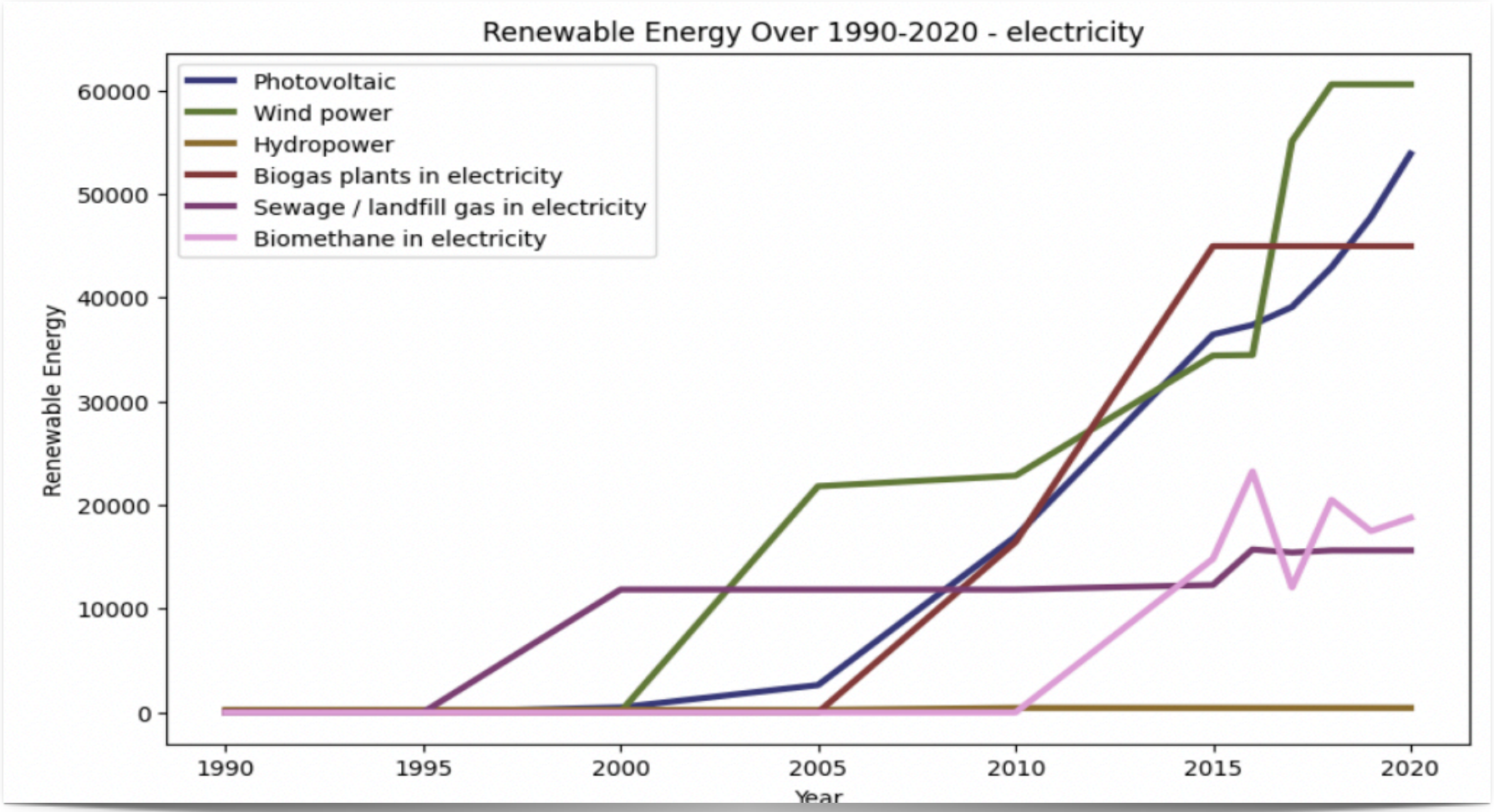
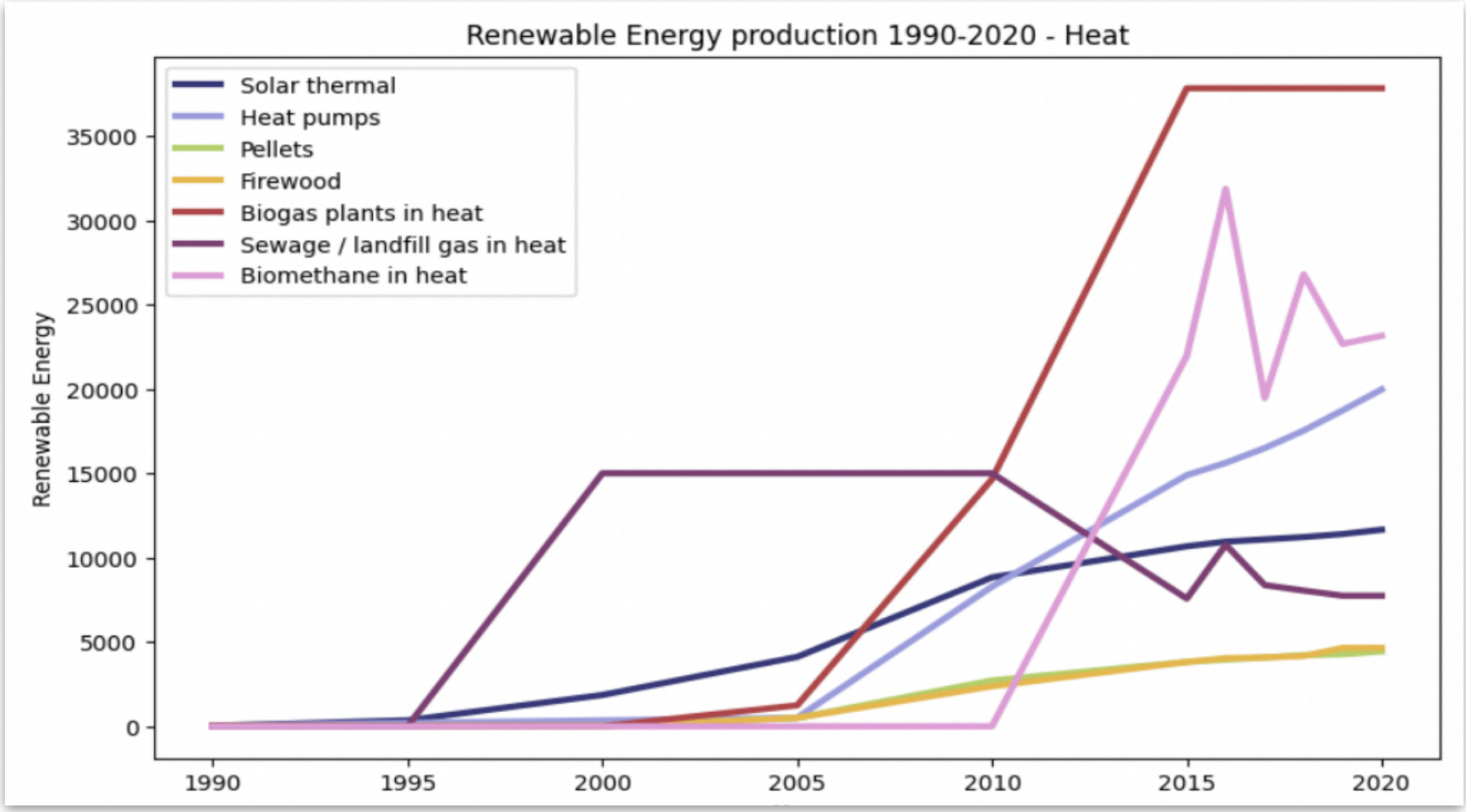
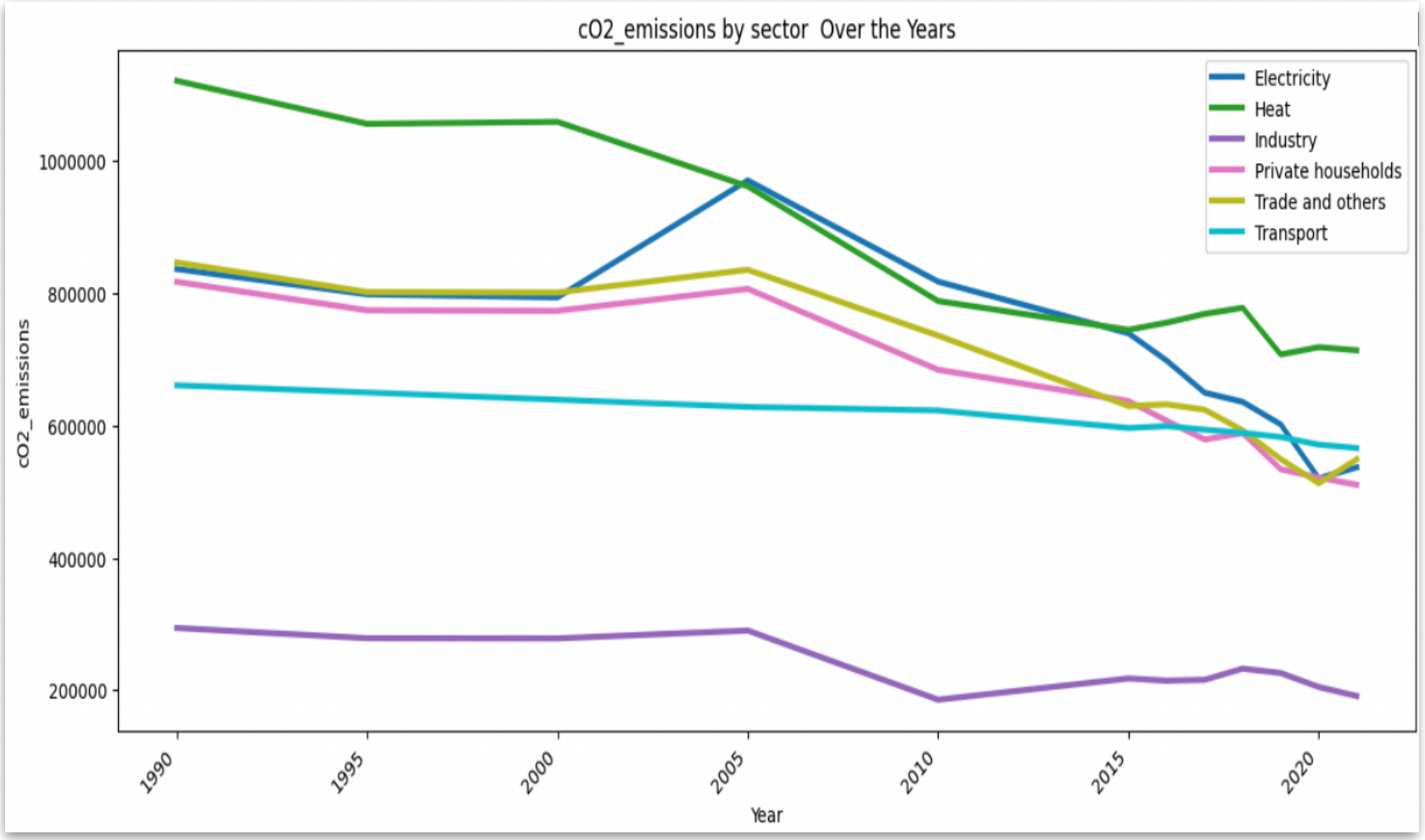
	CO2 Emission...	Natural Gas	District Heating	Heating Oil	Renewable H...	Fuel Mix Traffic	Electricity	Total	Share
1	Private households	238981.29622636...	11415.403693938...	98807.497200000...	1052.1870990381...	0	159997.92003818...	510254.30425752...	0.280945942100332
2	Trade+Other	120189.23487588...	85194.8032814226	36684.48	348.86081013613_	0	306686.89063074...	549104.26879818_	0.302336726651034
3	Industry	107276.17718935...	0	1630.8277646429_	0	0	82073.433625839_	190980.43857983_	0.105153800353769
4	Traffic	0	0	0	0	549788	16082	565862	0.311563530894865
5	Total	466446.707491605	96610.206975360...	137122.80496464_	1401.0479091743_	549788	564840.24429477_	1816201.0116355_	1
6	Share	0.2568254860025...	0.0531935652256...	0.0754997954995...	0.0007714167651...	0.3027087841476...	0.3110009523594...	1	-



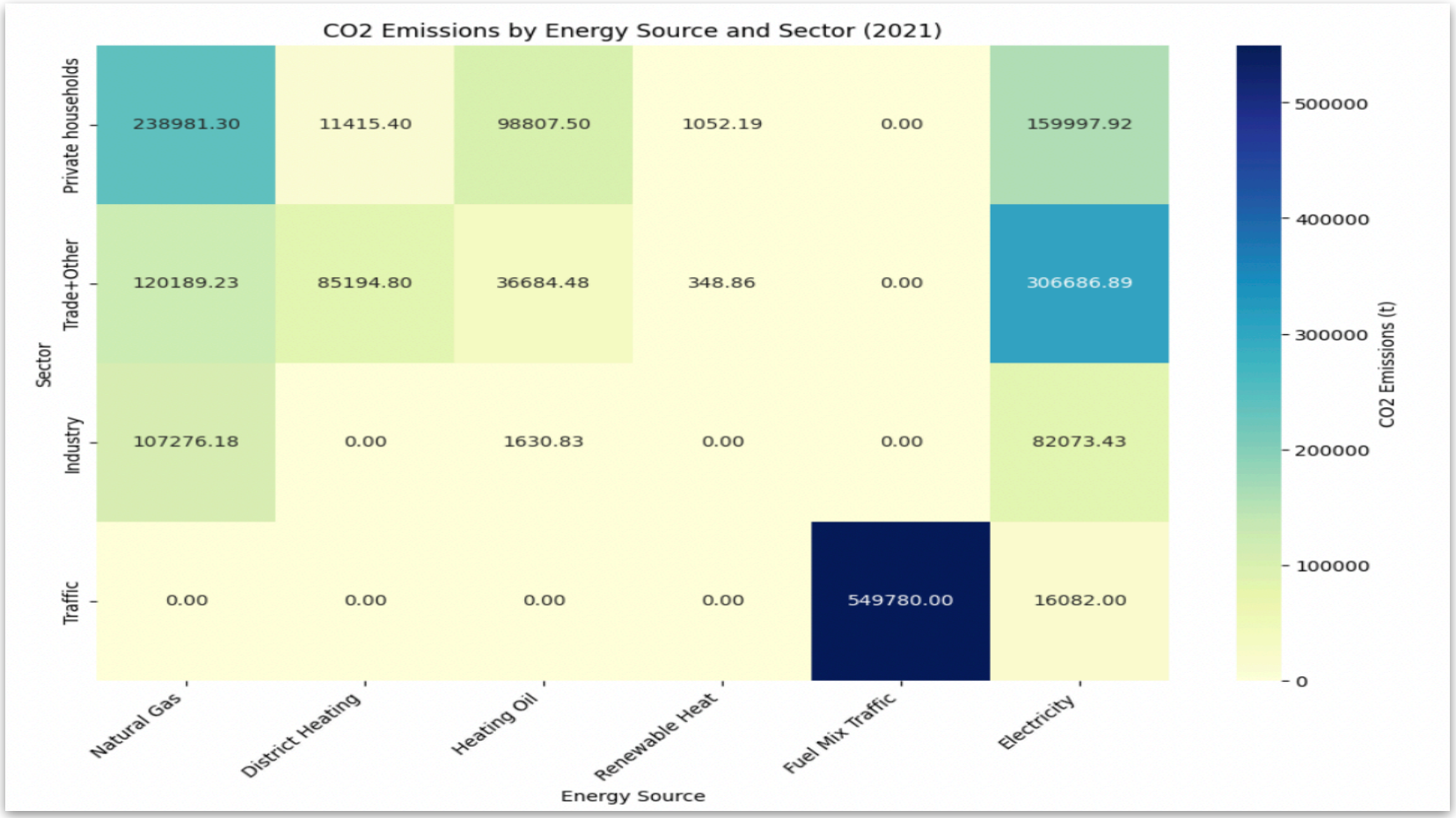
3. Results- Renewable Electricity



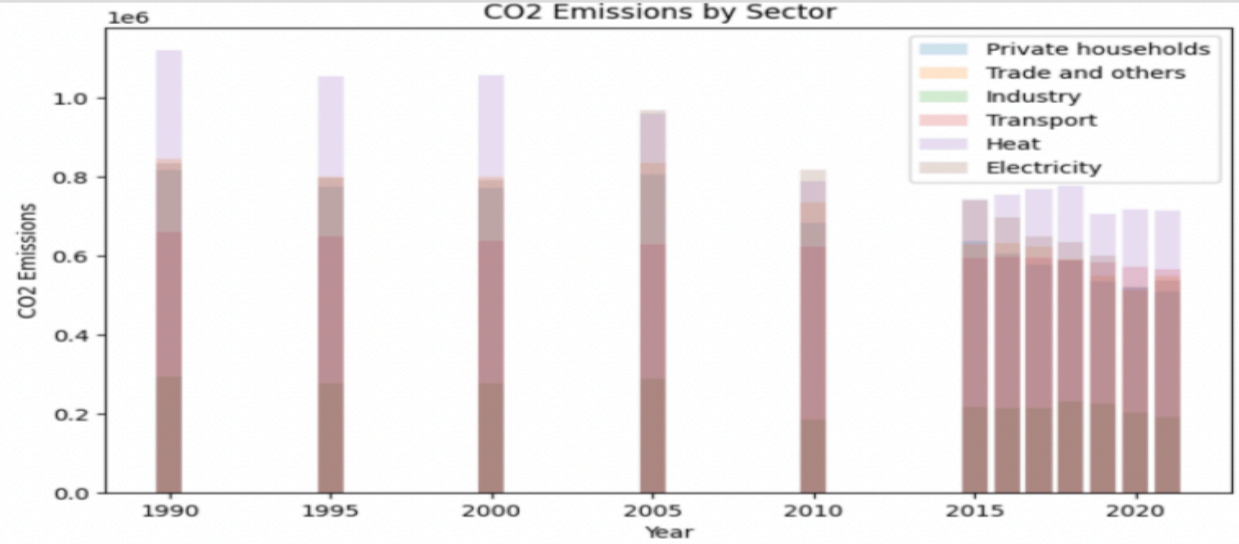
3. Results- Renewable Heat

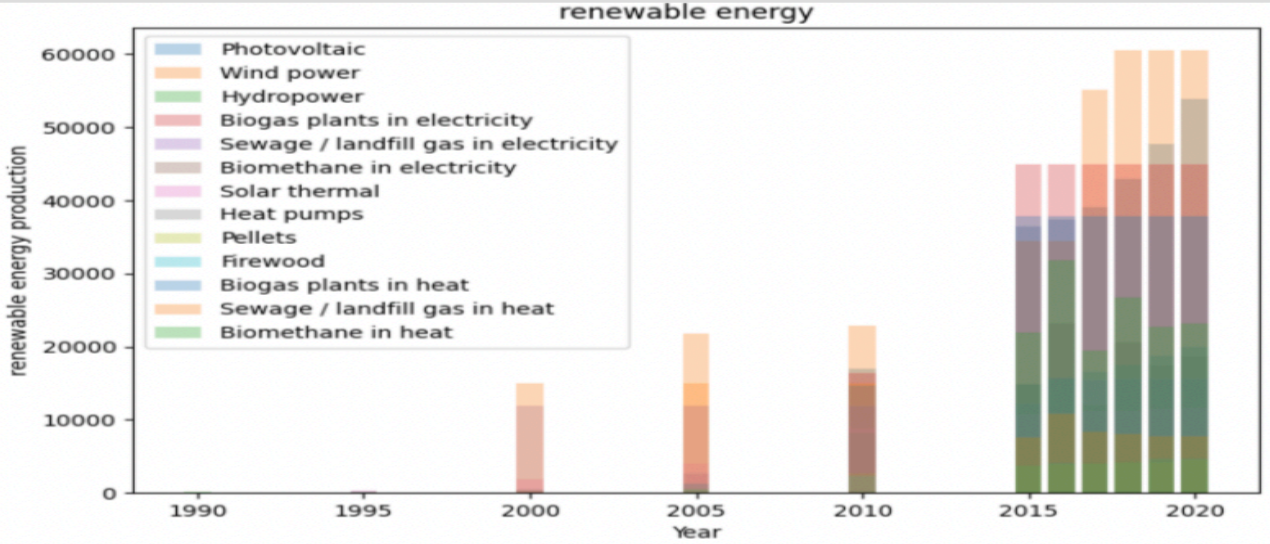


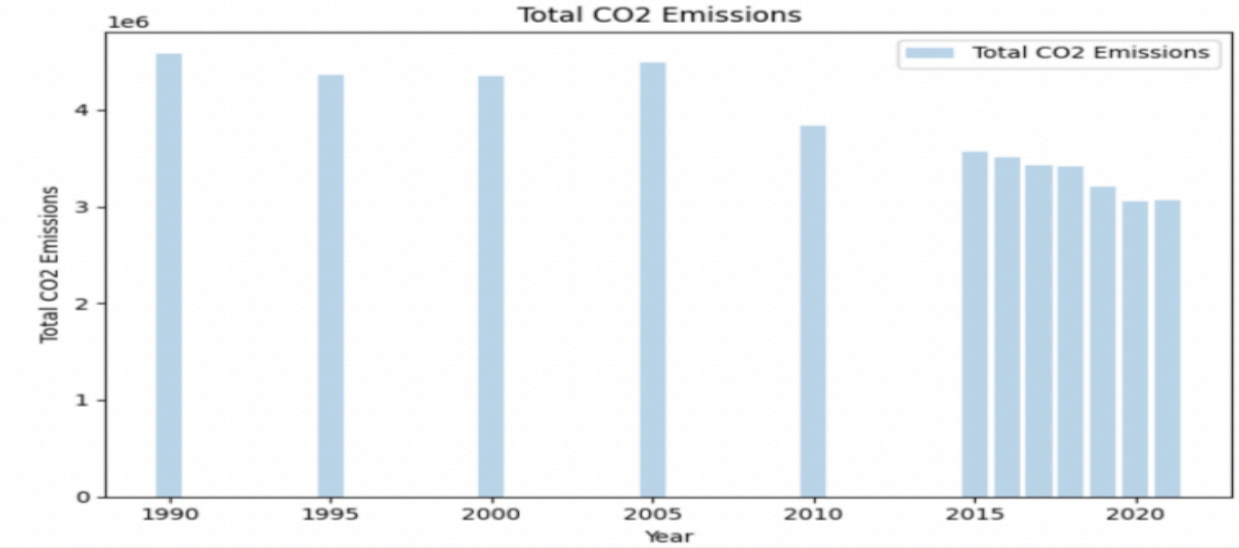
3. Results- Co2 Emissions

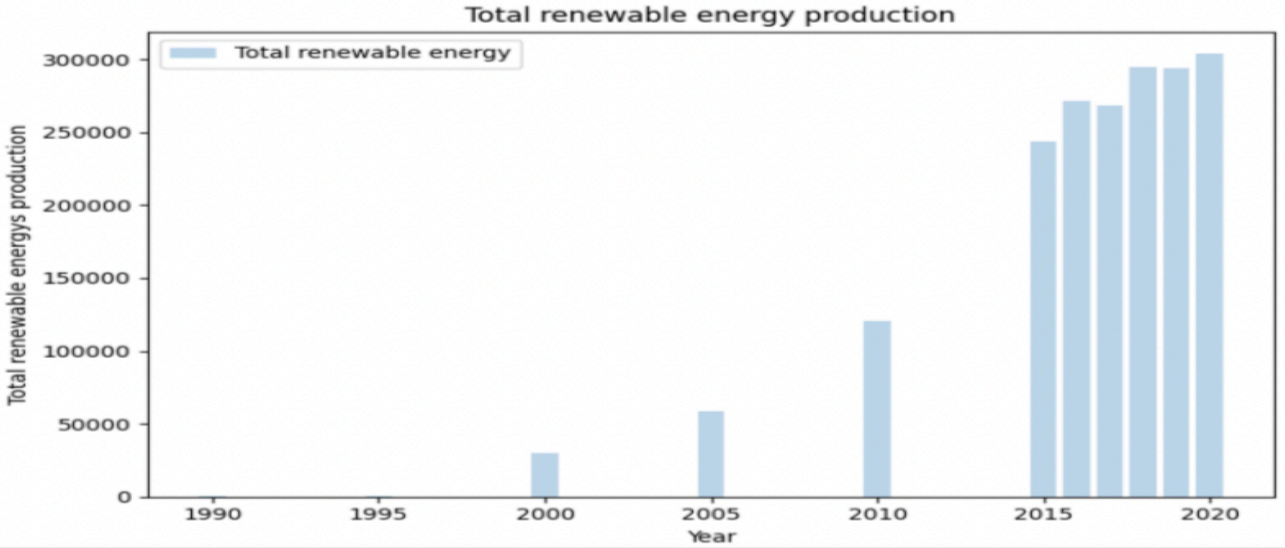


3. Results- Co2 2021


CO2 Emissions by Sector
1e6
CO2 Emissions
Year
Private households
Trade and others
Industry
Transport
Heat
Electricity


renewable energy
renewable energy production
Year
Photovoltaic
Wind power
Hydropower
Biogas plants in electricity
Sewage / landfill gas in electricity
Biomethane in electricity
Solar thermal
Heat pumps
Pellets
Firewood
Biogas plants in heat
Sewage / landfill gas in heat
Biomethane in heat


Total CO2 Emissions
1e6
Total CO2 Emissions
Year
Total CO2 Emissions


Total renewable energy production
Total renewable energys production
Year
Total renewable energy

3. Results

4. Conclusion:

- **The correlation between renewable energy** growth and **CO2 emission reduction.**
- **Continued monitoring and implementation of policies**
- **Improve in sectors showing slower declines.**
- **Combining data-driven** insights with **proactive policy measures and collaborative efforts.**
- **In future work, time series analysis.**

Question?

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References:

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