County of Essex

Windsor-Essex Climate Change Collaborative

County of Essex Regional Energy Plan

Report #2

Analytical Summary

Contents

2020 Analytical Report

Essex County Regional Energy Plan

1. Introduction

Community energy planning considers local energy flows of natural gas, electricity, gasoline, and diesel that impact the activities within a community. Based on the analysis of local and energy industry data and global best practice, the process identifies solutions to increase efficiency from supply through distribution to end-use (including homes, buildings, industry and transportation) recognizing that improved energy efficiency and alternative energy sources can reduce overall energy costs for residents and local businesses as well as lower greenhouse gas (GHG) emissions.

The analytical work includes the following key steps:

1. Establishing a baseline for energy use, energy-related emissions and energy costs across the Essex County community for 2019.
2. Establishing goals for energy use, energy-related emissions and energy costs for 2041.
3. Modelling the base case (i.e., energy use, energy-related emissions and energy costs in 2041 with no action).
4. Undertaking efficiency simulations (i.e., energy use, energy-related emission and energy costs in 2041 when a variety of energy efficiency measures are considered) that consider global best practices and local opportunities.
5. Recommending a preferred strategy to achieve the 2041 goals.
6. Identifying priority projects for the first five years.

This report summarizes the analytical findings arising from steps 1 to 4 of the project methodology.

2. Context

Essex County's community energy planning process is a cross-sector collaboration, drawing strength from the expertise and demonstrated leadership in Essex County and Project Working Team (PWT) and Community Task Force (CTF) members. See *Report 1 – Rationale and Scope* for the structure and composition of the PWT and CTF, summarized in Figure 1, below.

The Essex County community energy planning process is designed for implementation and is comprised of a set of five documents:

1. **Rationale and Scope Report** summarizing for the community energy planning process
2. **Analytical Report** summarizing the evidence-based rationale supporting the community energy planning process *(this report including appendices)*
3. **Recommendations Report** summarizing the recommendations from the PWT based on the findings of the analytical process
4. **Essex County Strategy and Implementation Plan**

5. **Engagement Report** summarizing the engagement process that informed the strategy.

See section 10 for the list of appendices that support this report.

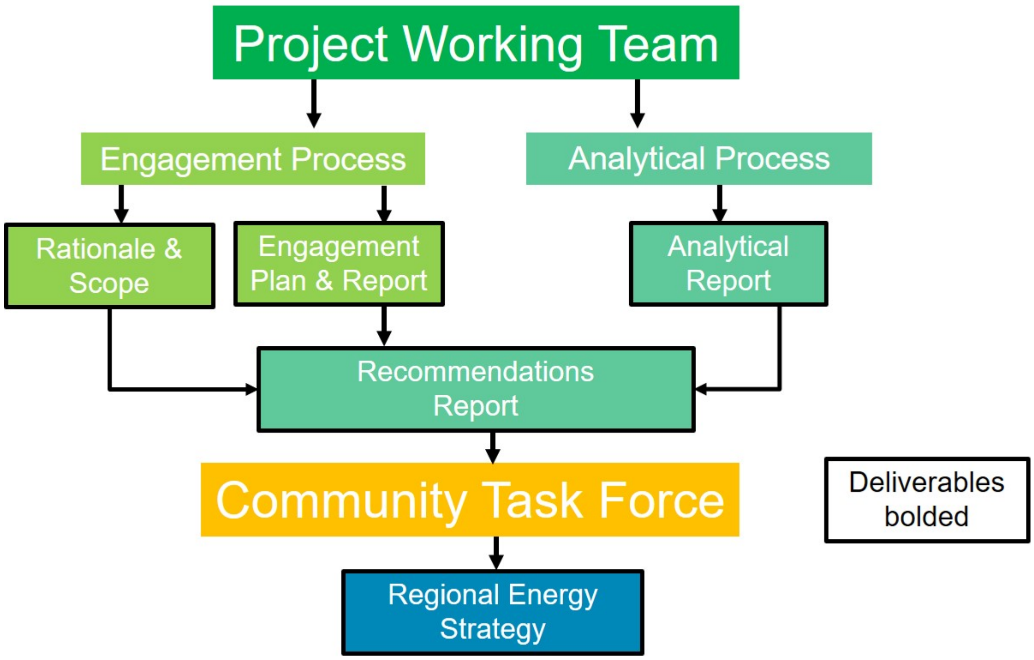

Figure 1: Schematic of project governance and deliverables (i.e., the five reports that comprise the documentation of the community energy planning process).

3. Analytical Framework

Table 1 describes the scope of the process which established the analytical framework for the collection, assessment and presentation of data and information.

Table 1: Analytical framework

Item	Scope
Geography level 1	County of Essex
Geography level 2	Municipalities of Amherstburg, Essex, Kingsville, Lakeshore, LaSalle, Leamington, and Tecumseh
Baseline year	2019
Planning horizon	2041 (indicative to 2050 to align with Federal goals)
End use sectors	Residential, commercial, institutional, industrial, transportation, and greenhouse sector
Sub-sectors	Municipal corporation (included in institutional)
Utilities / Fuels	Water, wastewater, electricity, natural gas, diesel, gasoline, biofuels, and local solar photovoltaics and thermal
Energy end use	Heating, domestic hot water, cooling, lighting, other power, industrial process, greenhouses, and transportation
Energy distribution	Electricity, natural gas, district energy
GHG stationary	Energy-related scope 1[1] and 2[2] for all geographic levels, sectors, utilities, and fuels. Carbon sequestration is not included.
GHG mobile	Energy-related scope 1 and 2 County-wide and fuels
Analytical profiles	Source energy use[3], site energy use[4], GHG emissions (based on source energy), cost (based on source energy), and water consumption[5]
Benchmarks	Canada, Ontario, and selected international
Assessment profiles	Impacts of (or on) municipal, utility and other plans, economic development, health and social factors and policy, practice, and institutional structures.

Seven energy planning districts (Figure 2) were established to align with the municipal boundaries within Essex County.

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[1] Scope 1 refers to GHG emissions from energy use or fuel burned inside the County.

[2] Scope 2 refers to GHG emissions from fuel for electricity and all transportation losses outside the County. No count for fuel exploration, agricultural and GHG emission in products consumed inside the County.

[3] Source energy considers all energy flows from production to end-use.

[4] Site energy considers the energy use of at the meter by end-users (e.g., homes, buildings, industry, and transportation).

[5] Municipal water supply only.

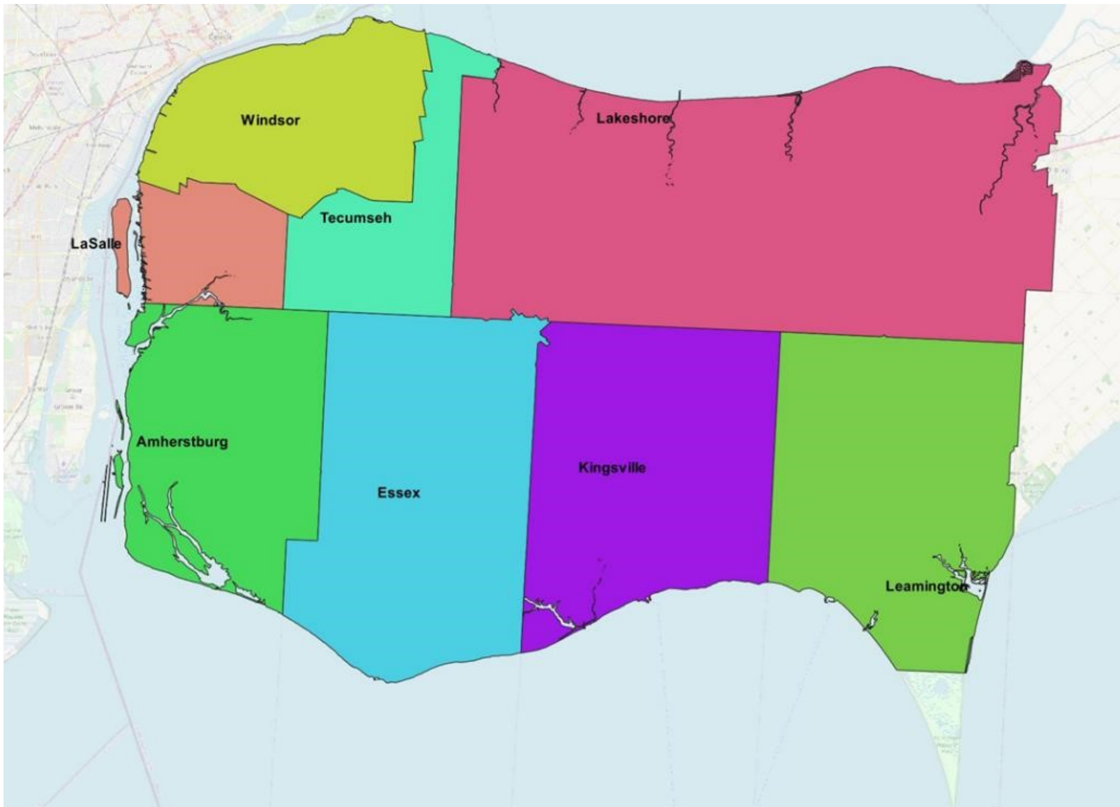

Figure 2: Energy planning districts for the Essex County Regional Energy Plan (excluding Windsor).

4. Methodology

What data is needed to inform the community energy planning process?

The following section is a summary of the data, information and assumptions that informed the analytical process.

4.1 Data and Information Gathering

Considerable data and information were gathered to support the analytical process and the development of goals, strategic objectives, targets, priority projects and milestones. All data pertains to activities occurring within the municipal boundary of Essex County. Additional detail on the type, source and form of data and information collected to support the planning process is found in the analytical documentation prepared for the PWT.

4.2 Framing Goals

Energy efficiency and emissions framing goals were established. The year 2041 was chosen to align with Essex County's planning framework. Framing goals were referenced to a 2019 baseline and selected independently of the Base Case. Framing goals were established to evaluate the performance of the Base Case and Efficiency Case simulations.

4.3 Base Case Assumptions

The Base Case is a "business-as-usual" picture of the future to 2019. To create this picture, the PWT established several assumptions on what business-as-usual looks like. Their approach was to include only short-term assumptions where legislation is already passed (e.g. Ontario Building Code) or where the technical evidence is overwhelming (e.g. average vehicle efficiency gains).

This means the Base Case does not reflect individual views of how Canada's energy and emissions future might evolve.

The PWT instead gave priority to measures that Essex County can influence, more-or-less, within the framework of current legislation. This approach underlines the opportunity and responsibility for individual communities to take the lead in dramatically reducing their GHG emissions, even with policy fluctuations going on around them. It also underscores the need to update the strategy and implementation plan every 5 years to respond to changes in legislation, policy, and technical evidence.

The integrated analysis of the energy, GHG emissions and cost footprint of all energy end-use sectors in Essex County required alignment on a considerable number of interrelated assumptions. Ensuring that assumptions aligned and integration of data was as accurate as possible relied on the collaboration of subject matter experts across the PWT. Additional detail on the assumptions used to establish the Base Case is found in the analytical documentation prepared for the PWT.

4.4 Data Assessment

Figure 3 illustrates the Integrated Workbook (IW) that supported simulations of different efficiency scenarios ("Efficiency Cases") to test their ability to achieve energy and emissions goals. The IW was structured by EPD. The Efficiency Cases allow for a wide range of opinions to be simulated and tested against the conservative Base Case.

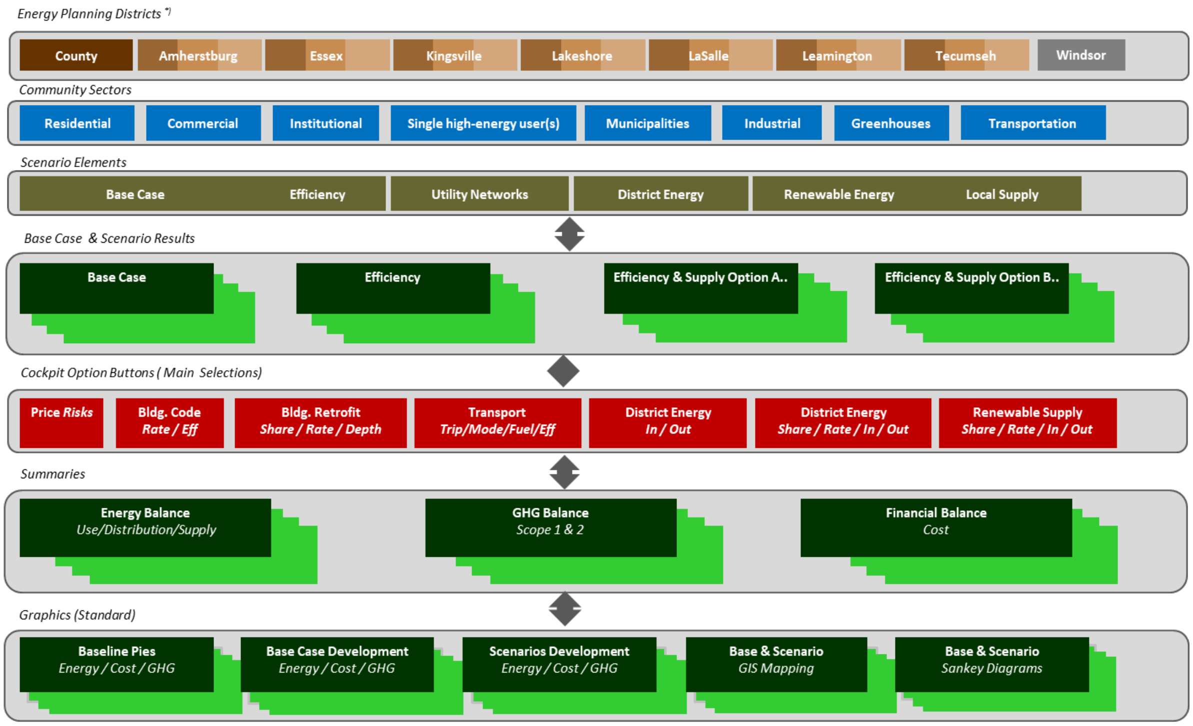

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Figure 3: Dashboard of the Integrated Workbook that supported simulations of different energy efficiency scenarios.

5. Baseline Findings

What is Essex County's starting point?

The following summarizes the main baseline findings for source energy, emissions, and cost in 2019.

5.1 Energy Consumption

In 2019, Essex County's total source and site energy use were 52 terajoules[6] (TJ) and 43 TJ, respectively. Due to its size and importance in the local economy, the greenhouse sector consumed 38% of total source energy. The industrial sector, including greenhouses, consumed half of Essex County's total source energy use. Transportation consumed almost one fifth of total source energy while the residential sector consumed almost a quarter of total source energy (see Figure 4).

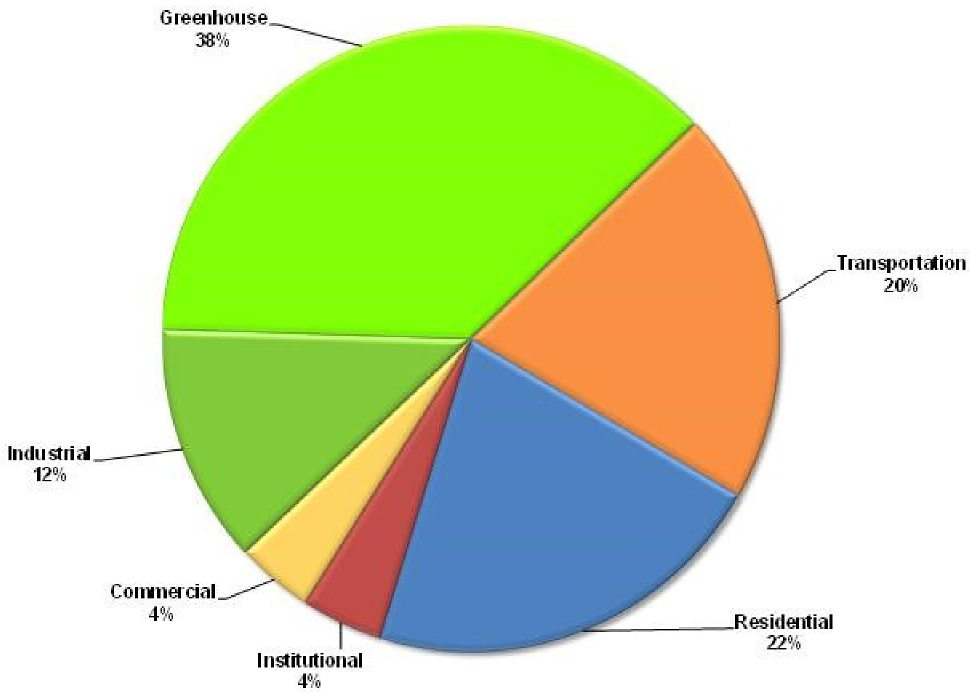

Figure 4: Essex County source energy use (%) by sector in 2019

The County of Essex's corporate energy use (e.g., county and municipal facilities, fleet) represented only 1.1% of the community's source energy use in 2019. This highlights that while

[6] A joule is a measure of energy. A terajoule (TJ) is equal to one trillion (10^{12}) joules. About 63 TJ of energy was released by the atomic bomb that exploded over Hiroshima. In 2017 Hurricane Irma was estimated to have a peak wind energy of 112 TJ.

the County and municipalities can lead by example, meaningful energy system changes in Essex County will require community-wide action.

System losses[7] accounted for approximately 21% of source energy use in 2019 (Figure 5). The largest system losses are associated with electricity.

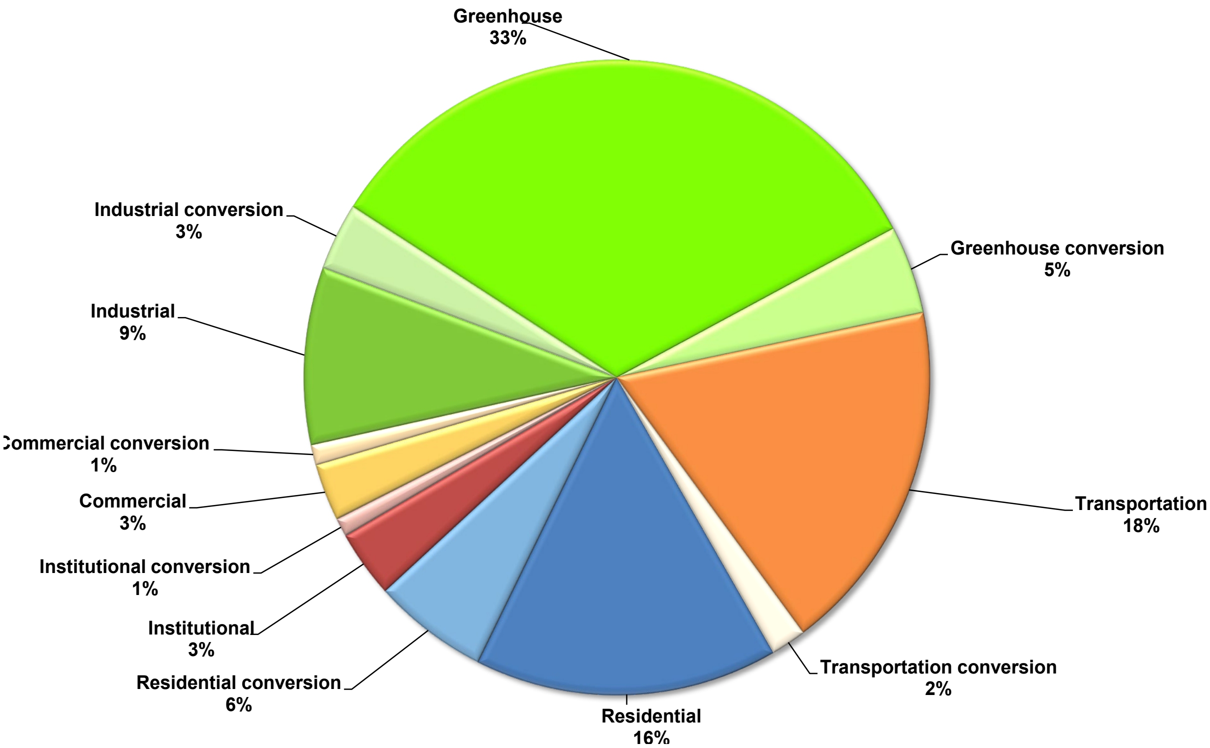

Figure 5: Essex County source energy use (%) by sector in 2019, showing system losses associated in each sector.

[7] System losses include 1) conversion losses which occur when energy is transformed from one form to another (e.g., natural gas is used to create electricity) and 2) transmission and distribution losses which occur when energy is moved from one place to another (e.g., electricity is conveyed from generating facilities to end-users over transmission lines).

5.2 GHG Emissions

In 2019, Essex County emissions were 2,212,000 metric tons (MT), or 11.5 MT for every resident. This is equivalent to 285 trillion smartphones charged or 5.5 trillion miles driven by an average passenger vehicle.[8] In section 5.5, we compare these emissions to national and provincial averages and global best practices (see Table 2).

The greenhouse sector makes the largest contribution to emissions (41%) followed by transportation (29%) (Figure 6). These two sectors combined contribute more than two-thirds of emissions. The residential sector contributes 15% (Figure 6).

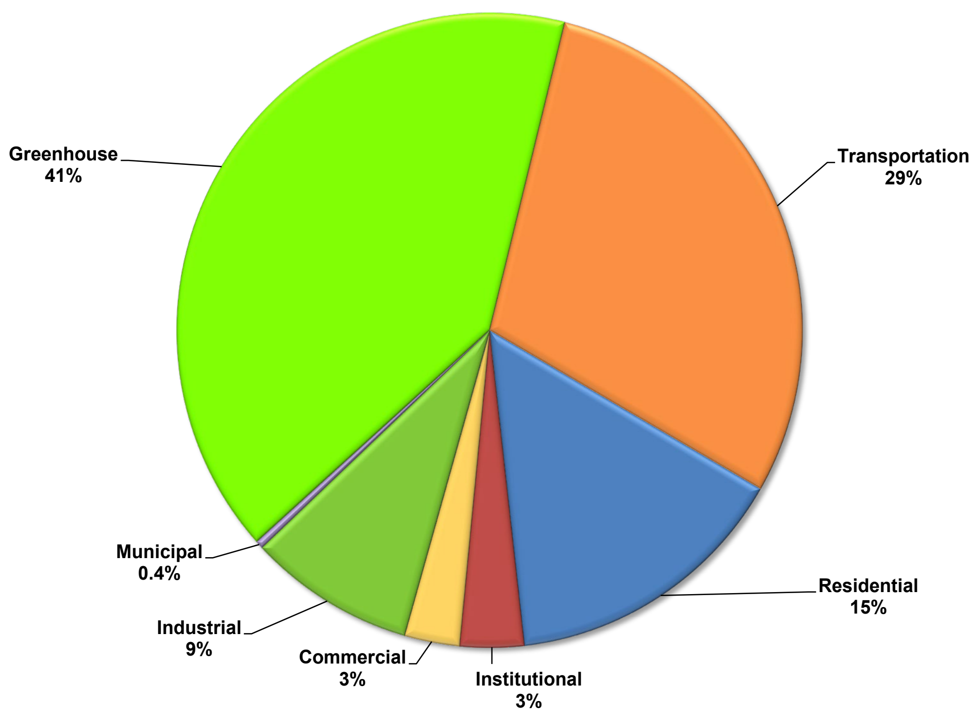

Figure 6: Essex County emissions (%) by sector in 2019

The use of natural gas contributes two-thirds of Essex County's emissions (Figure 7), while gasoline contributes almost a quarter of emissions. Only 3% of emissions arise from the community's use of electricity (Figure 7). From a GHG emissions perspective, these results underscore the need to address heating, which is the primary use of natural gas in homes and buildings.

[8] Sourced at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

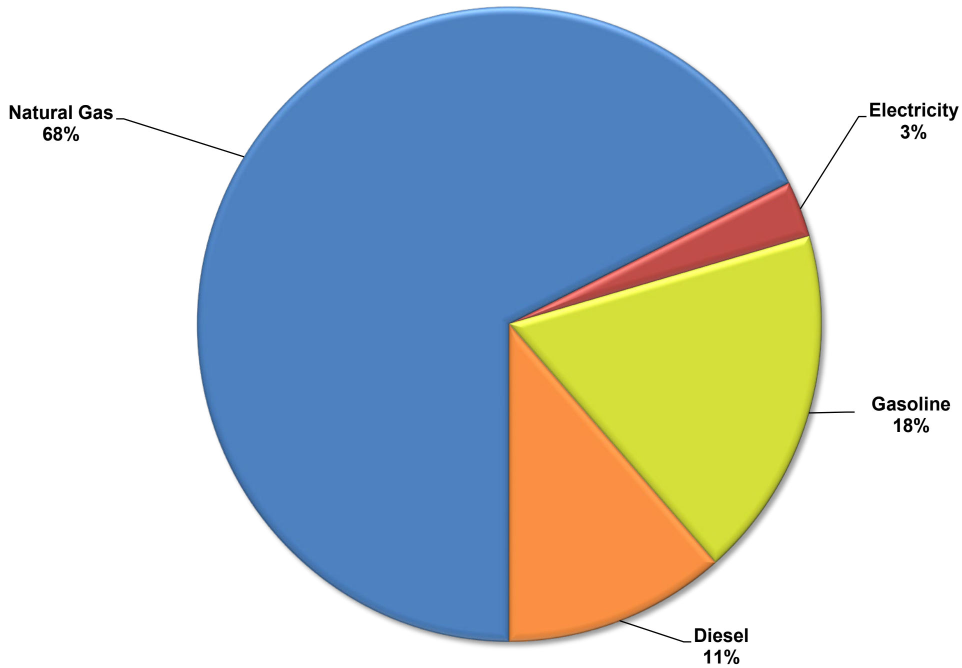

Figure 7: Essex County emissions (%) by utility in 2019.

5.3 Energy and Water Costs

In 2019, the Essex County community spent $820 million ($4,300 per resident) on energy and water[9] for all transportation, residential, commercial, and institutional activities. Most of the energy dollars leave the community – while some of the money spent on energy benefits local utilities, local energy dollars also go to Western Canada (oil, natural gas) and elsewhere in Ontario (centralized electricity generation). Transportation accounts for 40% of costs. The residential sector and the greenhouse sector account for 27% and 15% of costs, respectively (Figure 8).

Electricity comprises 31% of energy and water costs. Transportation fuel (gasoline and diesel) comprise 39% of costs. Natural gas comprises 20%, while water comprises 10% (Figure 9).

Approximately 21% of the energy that Essex County residents and businesses pay for does not reach homes, buildings, or vehicles. This energy is primarily lost as heat when one form of energy is converted to another and through transmission and distribution. Electricity accounts for most of these costs. This highlights the opportunities to consider energy solutions that reduce system losses.

[9] Municipal water service only. This does not include other water takings in the County of Essex.

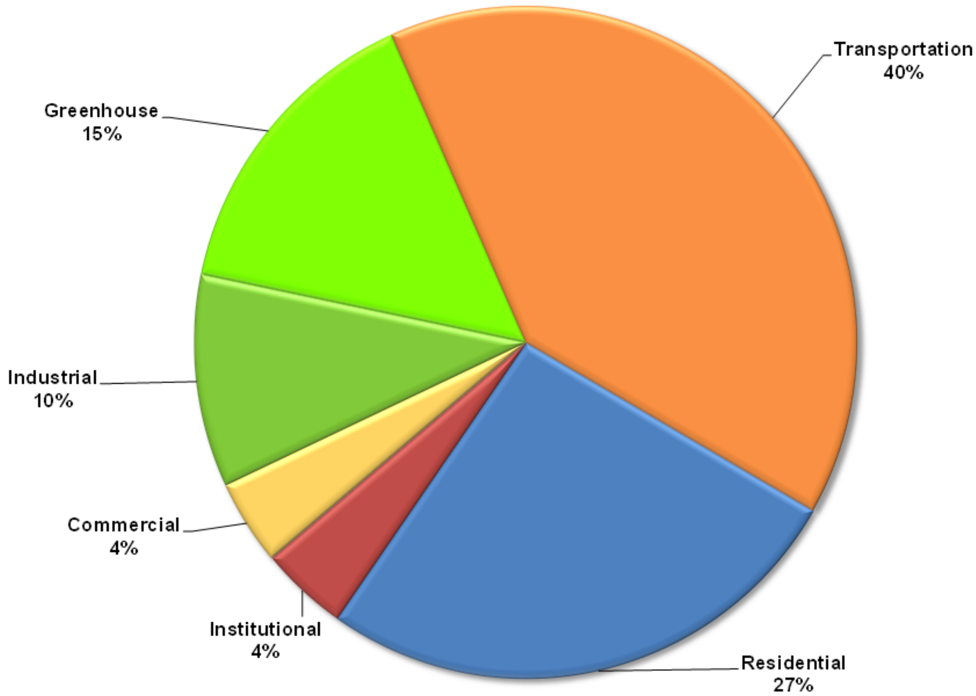

Figure 8: Essex County energy and water costs (%) by sector in 2019.

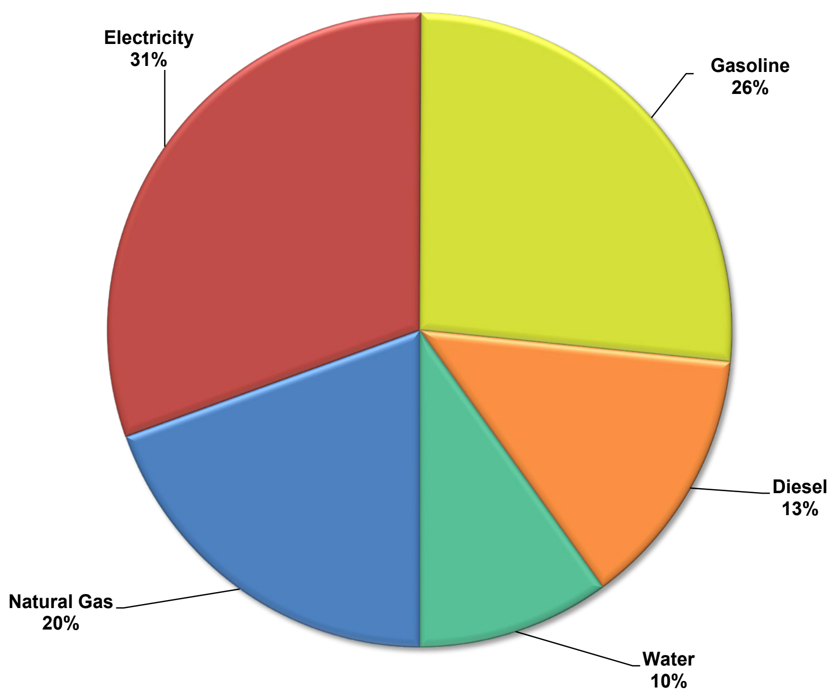

Figure 9: Essex County energy and water costs (%) by utility in 2019.

5.4 Municipal Water Consumption

In 2019, the Essex County community consumed 27 million cubic metres (m^3) of municipal water[10] (on average 143 m^3 per resident) (Figure 10). The residential sector consumed more than half of Essex County's municipal water consumption, followed by the greenhouse sector at 26%. See Section 5.5 for provincial comparators.

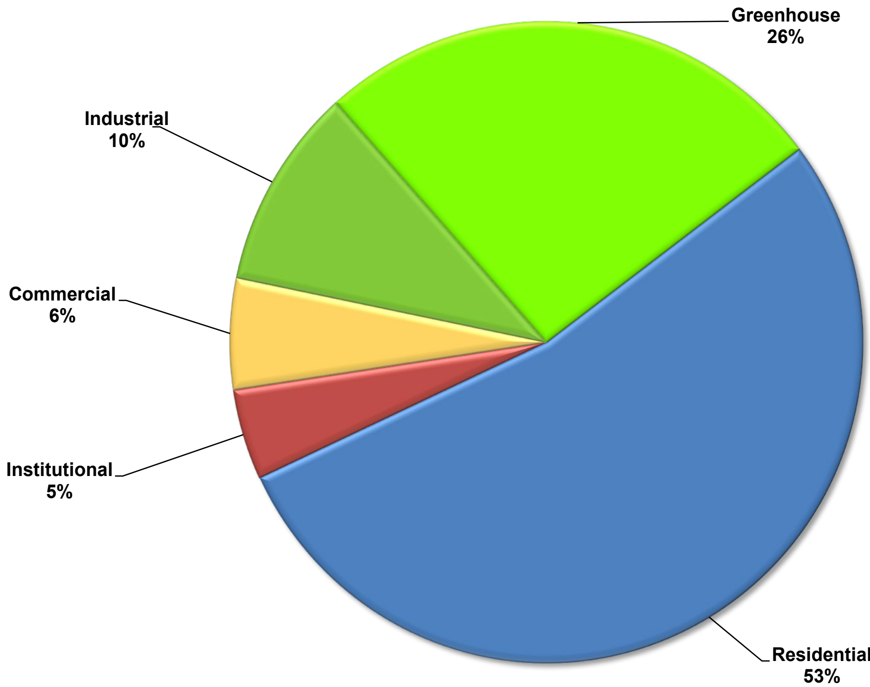

Figure 10: Essex County municipal water consumption (%) by sector in 2019.

5.5 Benchmarking

Essex County's baseline data was compared with several comparable provincial, national, and global benchmarks to understand the opportunity to deliver community benefits (Table 2). The following observations can be made:

- on average, homes and buildings in Essex County are approximately half as efficient as global benchmarks
- energy use per home is higher than the national and provincial average
- energy use in the residential sector per square metre (m^2) is the same as the national average but more than twice global best practice
- emissions per capita were higher than national and provincial averages
- per capita emissions are five (5) times global best practice (3 times global best practice if the contribution of the greenhouse sector is removed and about eight (8) times the Government of Canada target for 2050 based on the Paris Climate Agreement.

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[10] This is consumption from municipal water services. It does not include direct use from surface or groundwater extraction.

Table 2: Provincial, national, and global comparison of Essex County energy use and GHG emissions.

Indicator	Essex County Baseline	Canada Average	Ontario Average	Comparable Best Practice
Energy use/household (GJ)	130	106	107	68[11]
Residential sector energy use per m^2 (GJ)	0.78	0.79	N/A	0.29[12]
Non-residential sector energy use per m^2 (GJ)	1.64	1.65	N/A	0.72[13]
Emission per capita (MT CO_{2e})	11.5	9.7	6.2	2.5[14]

Residential municipal water use is approximately the same as the Canadian average. Municipal water consumption is 14% higher than the provincial average for household use and approximately 10% higher than the provincial average for all uses.[13]

[11] Danish average

[12] German A-rated home

[13] German average

[14] Copenhagen (capital city) is an example of community scale systematic best practice. [13] This is consumption from municipal water services. It does not include direct use from surface or groundwater extraction. This will be estimated in future versions of the report.

6. Base Case Findings

Where is Essex County headed if no local action is taken?

The following is a summary of the main Base Case (i.e., business-as-usual) findings for source energy, site energy, emissions, and energy cost for Essex County in 2041.

6.1 Energy Consumption

By 2041, population and employment growth are estimated to increase site energy use by 16% and source energy use by 21% (Table 3). Population and the workforce are estimated to increase by 15% and 17%, respectively, during this time (Table 3). There is little change in the contribution of sectors to source energy consumption between 2019 to 2041 (Table 4).

6.2 GHG Emissions

Despite population and employment growth, GHG emissions are expected to remain relatively constant (approximately a 3% increase) by 2041 due to a projected increase in vehicle efficiency and reduction in the carbon intensity of the natural gas grid (Table 3). There is little change in the contribution of sectors to GHG emissions between 2019 to 2041 (Table 4).

6.3 Utility Costs

Utility costs are estimated to increase by 125% to 300% by 2041 (Table 3). These increases reflect both higher prices and population and employment growth. The range in estimated costs reflects a low and high scenario for future energy costs. There is little change in the percentage amount that each sector pays for energy between 2019 to 2041 (Table 4).

6.4 Municipal Water Usage

Municipal water consumption is projected to decrease by 13% (Table 3).

Table 3: Summary of Baseline (2019) data and Base Case estimates for several indicators in Essex County

Indicator	2019	2041
Population	192,000	220,000
Workforce (estimated)	~70,000	~ 82,000
Total source energy (TJ)	52	59
Total site energy (TJ)	43	50
Municipal contribution to total source energy (%)	1.1	~ 1
Systemic losses (%)	21	22
Total GHG emissions (MT CO_{2e})	2,212,00	2,300,000
GHG emissions (MT CO_{2e}/capita	11.5	10.5
Total utility costs ($B)	0.82	1.9 to 3.1
Total municipal water consumption (m^3)	27,000,000	30,500,000
Average municipal water consumption (m^3) per capita	143	135

Table 4: Summary of Baseline (2019) data and Base Case estimates for percentage contribution to source energy, GHG emissions and utility costs in Essex County by sector.

Sector	2019 Source Energy (%)	2041 Source Energy (%)	2019 GHG Emissions (%)	2041 GHG Emissions (%)	2019 Utility Costs[15] (%)	2041 Utility Costs (%)
Residential	22	20	15	15	27	27
Industrial	12	13	8	10	10	10
Greenhouse	38	40	41	40	15	16
Commercial	4	4	3	3	4	4
Institutional	4	4	4	3	4	4
Transport	20	19	29	29	40	39

[15] Municipal water and energy costs

7. From Baseline to Base Case Highlights

Table 5 summarizes key findings for Essex County from Baseline (2019) to Base Case (2041).

Table 5: Summary of projected changes between 2019 and 2041 in Essex County for energy use, emissions, and energy costs.

2019 Baseline	2041 Business-as-Usual
Essex County used 52 Terajoules of energy.	Growth in population and employment increases energy use by 21%.
Greenhouse, residential and transportation sectors' source energy consumption represented 38%, 20% and 22% of total consumption, respectively.	No material change
On average, homes and buildings in Essex County are approximately half as efficient as global benchmarks.	The gap widens against global best practice
System energy losses represent 21% of the total source energy consumption in Essex County.	No material change
The County's and municipalities' corporate energy use for facilities and fleet represents only 1.1% of the community's total source energy use.	No material change
On average, Essex County residents release 11.5 metric tonnes of GHG emissions each year.	Reduces to 10.4 metric tonnes per capita due to a projected increase in new homes and buildings, vehicle efficiency and reduction of carbon intensity of the natural gas grid.
Emissions five times global best practice (three times global best practices if the greenhouse sector is removed) and about eight (8) times the Paris Agreement.	The gap widens against global best practices.
$820 million spent on electricity, natural gas, gasoline, and diesel within the community.	Spending estimated to increase to $1.9 billion (low risk cost profile) to $3.1 billion (high risk cost profile).
Most of the money spent on energy left the Essex County economy.	No material change

8. Efficiency Case Simulations and Results

How might Essex County change its energy future?

The following section provides a summary of the efficiency simulations and results. In total, three simulations were considered to identify an energy strategy for Essex County. The simulations considered different combinations of integrated energy-related measures for all sectors and energy uses, distribution, conversion, and fuels (Figure 11).

Figure 11: Energy-related measures considered in the efficiency simulations for Essex County.

Three simulations were developed to test their ability to achieve the following energy consumption, GHG emissions and economic framing goals:

Energy

- Reduce energy consumption (source energy/capita) by 50% by 2041 from 2019

Emissions

- Reduce absolute GHG emissions by 50% by 2041 from 2019
- Reduce absolute GHG emissions to meet the 2050 national commitments[16]

Water

- Reduce municipal water consumption (municipal water services m^3/m^2 GFA) by 20% for residential, commercial, institutional use.

Economic

- Cumulative saving of at least $100M by 2025 in support of about 1,000 new jobs
- Cumulative saving of at least $15Bn by 2041 to align with a flattened cost curve absorbing both inflation, along with economic and population growth.

The goal of the simulations was to find the right combination of measures to achieve or exceed all framing goals.

Measures were only considered if they were implementable with current technology and within current policy constraints. The level established for each measure also had to be defensible based on global best practices, industry trends and experience. Each simulation included:

  - All end-use efficiency measures, including transportation measures,
  - District heating,
  - Solar thermal,
  - Solar photovoltaic (PV),
  - On-site biogas usage in the greenhouse gas sector, and
  - CO_2 avoidance of the greenhouse sector through replacement of CO_2 injection.

In addition to energy, emissions and municipal water reductions, the utility savings that would flow to the community were also estimated.

[16] Based on the Paris Climate Agreement, this represents an 80% reduction in absolute GHG emissions by 2050 based on 1990 levels or a 86% reduction based on 2019 levels.

8.1 Simulation 1

Simulation 1 (see Table 6) was eliminated early in the process as it did not achieve any of the framing goals.

8.2 Simulation 2

Simulation 2 (see Table 5) gave the following results (Figure 12):

- emissions are 50% less 2019 by 2041, achieving the 2041 framing goal but misses the Federal targets
- energy efficiency is 34% higher than 2019 levels by 2041 but significantly misses the framing goal and global best practice
- municipal water efficiency is 17% higher than 2019 levels by 2041 but misses the framing goal
- cumulative cost reduction of at least \$9.5 to \$14 billion through 2041 but misses both framing goals (including job creation)[17]

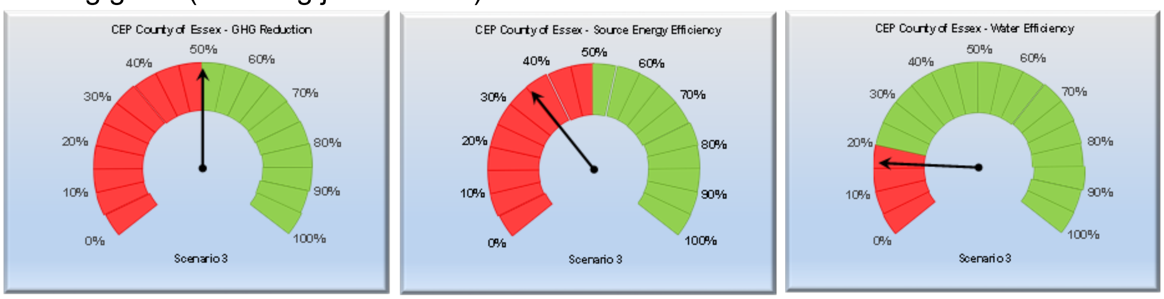

Figure 12: Results for Simulation 2 against 2041 framing goals. Arrow indicates percent reduction achieved for GHG emissions (left), energy use (middle) and municipal water use (right).

8.3 Simulation 3

Simulation 3 (see Table 6) gave the following results (Figure 13):

- emissions are 62% less than 2019 levels by 2041, exceeding the framing goal but misses the 2050 Federal targets
- energy efficiency is 43% higher than 2019 levels by 2041 but still does not achieve the framing goal and global best practice
- municipal water efficiency is 20% higher than 2019 values by 2041
- cumulative cost reduction of in the range of \$13 to \$18 billion through 2041[18], achieving both framing goals

[17] Cost reductions consider a low and high range of projected of cost increases.
[18] As above.

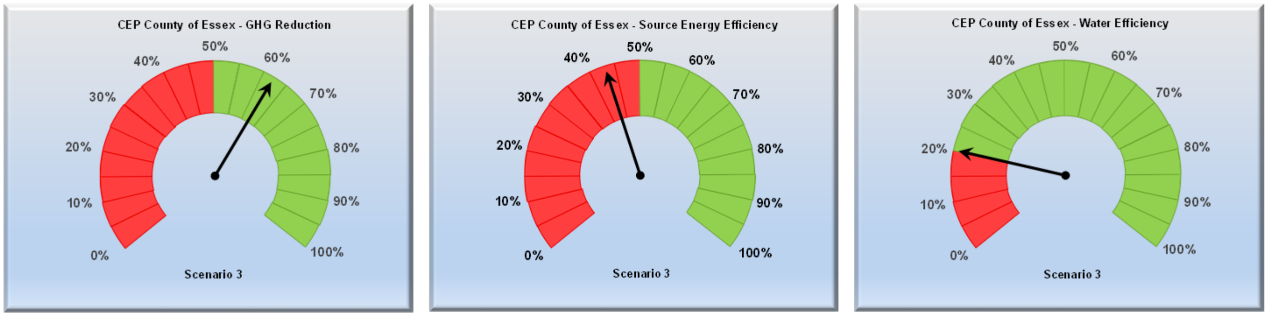

Figure 13: Results for Simulation 3 against 2041 framing goals. Arrow indicates percent reduction achieved for GHG emissions (left), energy use (middle) and municipal water use (right).

Table 6 describes the simulation elements, metrics, and targets for each simulation.

Table 6: Simulation elements and metrics used for Simulation 1, 2 and 3 for Essex County.

Primary Simulation Elements	Metric	Simulation #1	Simulation #2	Simulation #3
Reduce energy use in existing homes through energy retrofitting	Homes retrofitted	40%	80%	80%[19]
Reduce energy use in existing buildings through energy retrofitting	Buildings retrofitted	30%	60%	60%[20]
Include heat pumps in home and building retrofits outside District Energy areas	Share of retrofits	0%	0%	30%
Reduce future energy use by ensuring most new homes and buildings meet current and future Ontario Building Codes through performance transparency	Home and Build Energy Performance Label program	yes	yes	yes
Reduce future energy use by ensuring area developments of new homes and buildings exceed future Ontario Building Codes through energy and climate overlay planning	New construction above code	10%	20%	30%
Include heat pumps in new homes and buildings outside District Energy areas	Share of new construction	0%	0%	50%
Reduce energy used by industry by proliferating global best-practice industrial energy management	Year on year improvement	0.5%	1%	1.5%
Reduce energy use in existing commercial greenhouses through extensive energy retrofitting	Greenhouses retrofitted	30%	60%	60%[21]

[19] Efficiency per retrofit was modelled for all simulations. In Simulation #3, efficiency per retrofit was increased 20% beyond modelling.
[20] As above.
[21] As above.

Primary Simulation Elements	Metric	Simulation #1	Simulation #2	Simulation #3
Reduce future energy use by all newly constructed greenhouses by ensuring they meet or exceed global best practice energy efficiency	Greenhouses exceeding industry norms	10%	20%	30%
Reduce impacts from electricity use through the installation of solar power installed on rooftops and ground locations	Share of electricity supply	5%	10%	15%
Decrease energy impacts from heating and hot water use through the installation of solar thermal heating installed on homes and buildings	Heating and hot water needs in non-district energy areas	5%	10%	10%
Decrease energy impacts of heating and cooling homes and buildings through implementing district energy services in higher density areas	New homes and buildings served in high density areas	90%	90%	90%
	Existing homes and buildings served in high density areas	70%	70%	70%
Reduce energy and climate impacts from commercial greenhouses through the implementation of dedicated integrated energy supply solutions, including CHP and CO_2 injection	Combined heat and power	10%	20%	40%
	Local biogas	0%	10%	10%
	CO2 avoidance	10%	15%	15%
Reduce transportation energy impacts through reducing average trip length for Light-Duty Vehicles	Reduction average trip length	5%	15%	20%
Reduce transportation energy impacts by increasing the walking and cycling share of passenger kilometers travelled (PKT)	Increase active transportation	3%	5%	5%
Reduce transportation energy impacts through increasing bus share of passenger kilometers travelled (PKT)	Increase bus share	2%	3%	3%
Reduce transportation energy impacts through increased use of electric and other higher efficiency vehicles	Electric share of light duty vehicles	10%	50%	80%
	Electric share of transit vehicles	10%	30%	80%
	Electric share of heavy-duty vehicles	2%	10%	10%
	Year on year improvement of electric vehicle efficiency	1%	1%	1%
	Year on year improvement of gasoline/diesel vehicle efficiency	2%	2%	2%

9. Approved Efficiency Case

All three simulations are equally challenging to implement. Stress testing of the simulations underlines there is no single action that will put the community on a path to near net zero by 2050. Each simulated measure will require comprehensive, detailed public and private enabling plans.

The CTF approved Simulation 3 as the Efficiency Case for Essex County. Based on the results of the simulations, the CTF aligned on the following strategic goals:

- Increase community-wide energy efficiency by at least 50% by 2041 from 2019 levels recognizing selected efficiency measures would consider the entire system from supply through distribution to end-use.
- Enable transition to carbon neutrality by reducing GHG emissions by at least 60% by 2041 from 2019 levels.
- Increase municipal water efficiency by 20% by 2041 from 2019 levels.
- Reduce community-wide energy and water costs in the range of $13 to $18 billion through 2041.

By doing so, the intent of the CTF is to respect the science that supports the emissions reduction target of the International Panel on Climate Change while setting an emissions reduction goal that can be demonstratively implemented based on current global best practices and industry trends. Implementation of the Efficiency Case will put Essex County on a path to achieve the Paris Climate Agreement goal. Regular 5-year updates to the energy strategy will capture advances in local, regional, and global best practices to accelerate the transition to carbon neutrality during later years of implementation.

10. Energy Flows

Sankey diagrams were developed to visualize energy, emissions, and energy costs flow for:

- 2019 Baseline
- 2041 Base Case
- 2041 Efficiency Case

10.1 What are Sankey diagrams?

Sankey diagrams have been named after Irish Captain Matthew Henry Phineas Riall Sankey. He developed the diagram in 1898 to illustrate the energy efficiency of a steam engine. Sankey diagrams continue to be used today to show the energy flow through a system and to identify opportunities to improve efficiency.

10.2 Why is the Sankey diagram important?

Community energy planning considers all local energy flows from source to end-use to identify opportunities to increase efficiency from supply through distribution to end use.

A Sankey diagram illustrates the opportunity for efficiency at end-use (refer to green flows on the right of each of the following diagrams) as well as opportunities to improve system efficiency[22] (refer to light grey and dark grey flows on the right of each of the following diagrams). Energy use, emissions, and cost flow from the left to right through the system. Figure 1 describes how to read a Sankey diagram.

10.3 Essex County Sankey diagrams

Sankey diagrams were developed to show the energy use (Figures 2a, 2b, 2c), emissions (Figures 3a, 3b, 3c) and cost (Figures 4a, 4b, 4c) flows for Essex County 2019 baseline (Figures 2a, 3a, 4c) and in 2050 under two scenarios: Base Case (Figures 2b, 3b, and 4b) and REP Efficiency Case (Figures 2c, 3c and 4c). They illustrate efficiency measures only and not supply measures.

[22] Conversion losses occur when energy is transformed from one form to another (e.g., fossil fuel is converted to electricity). Additional system losses occur when energy is moved from one place to another (e.g., the transmission of electricity from point of generation to homes and businesses), or from one system to another.

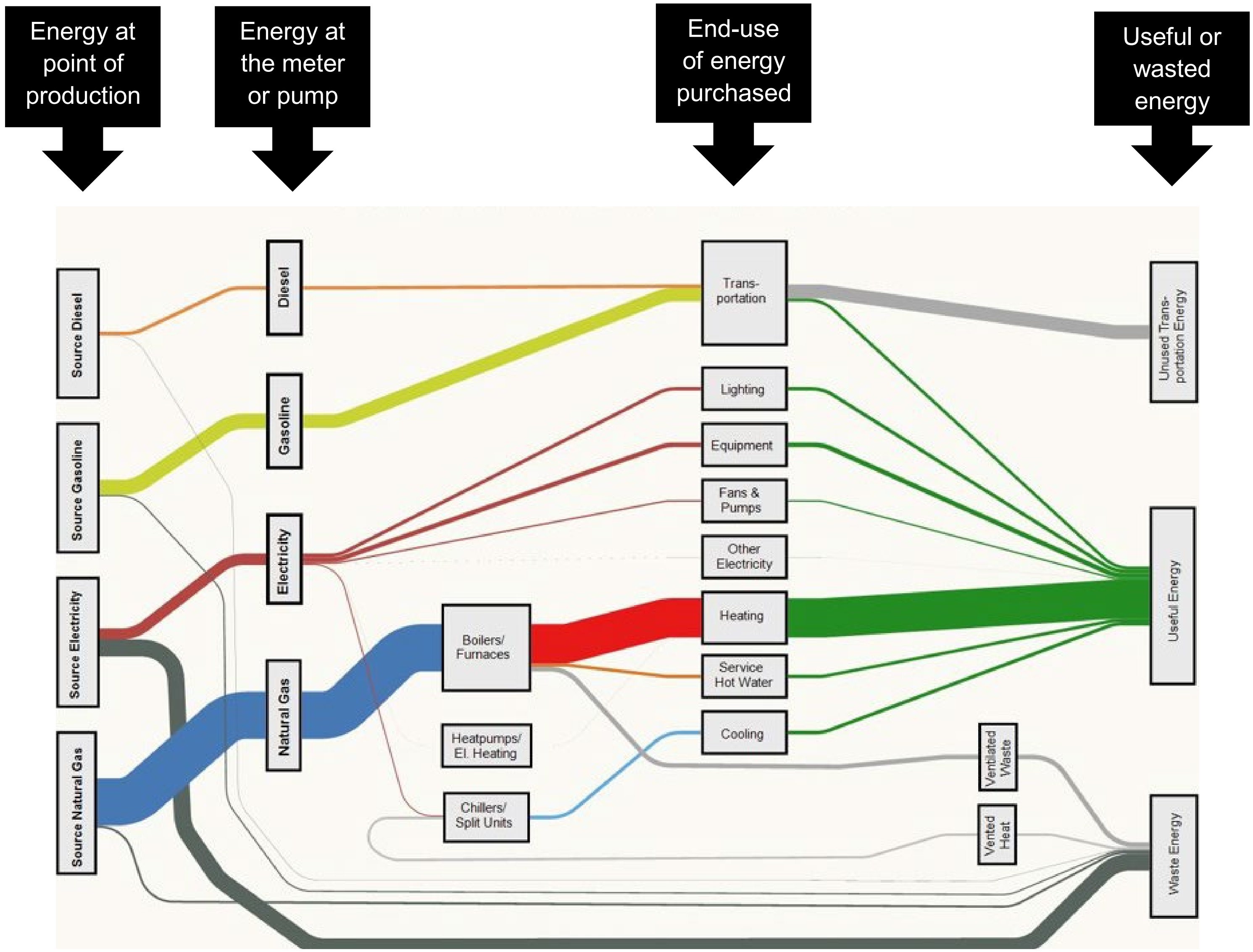

Figure 1: How to read the Sankey diagram (2019 source energy).

10.3.1 Energy consumption

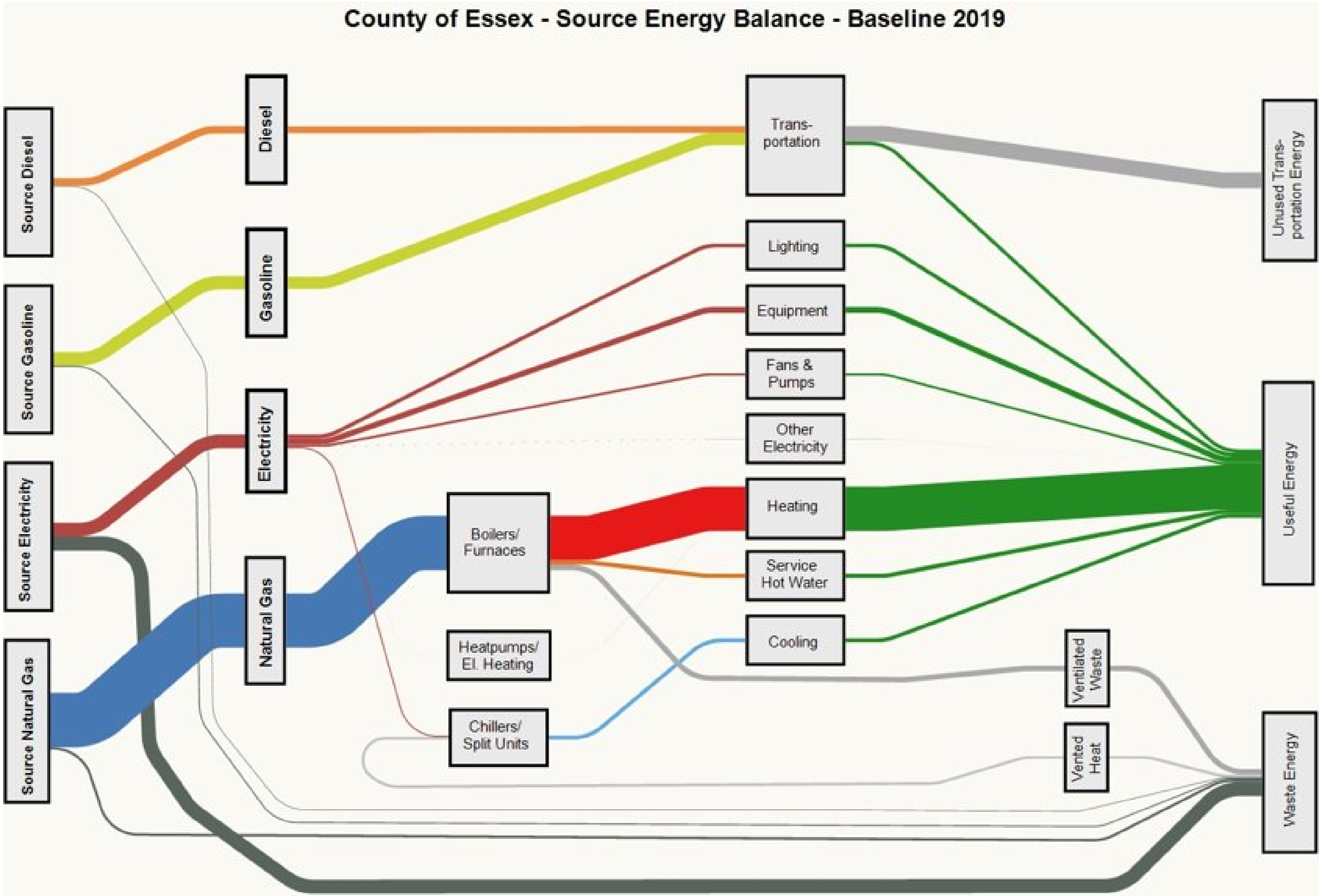

Figure 2a: Essex County Sankey diagram for 2019 baseline source energy use.

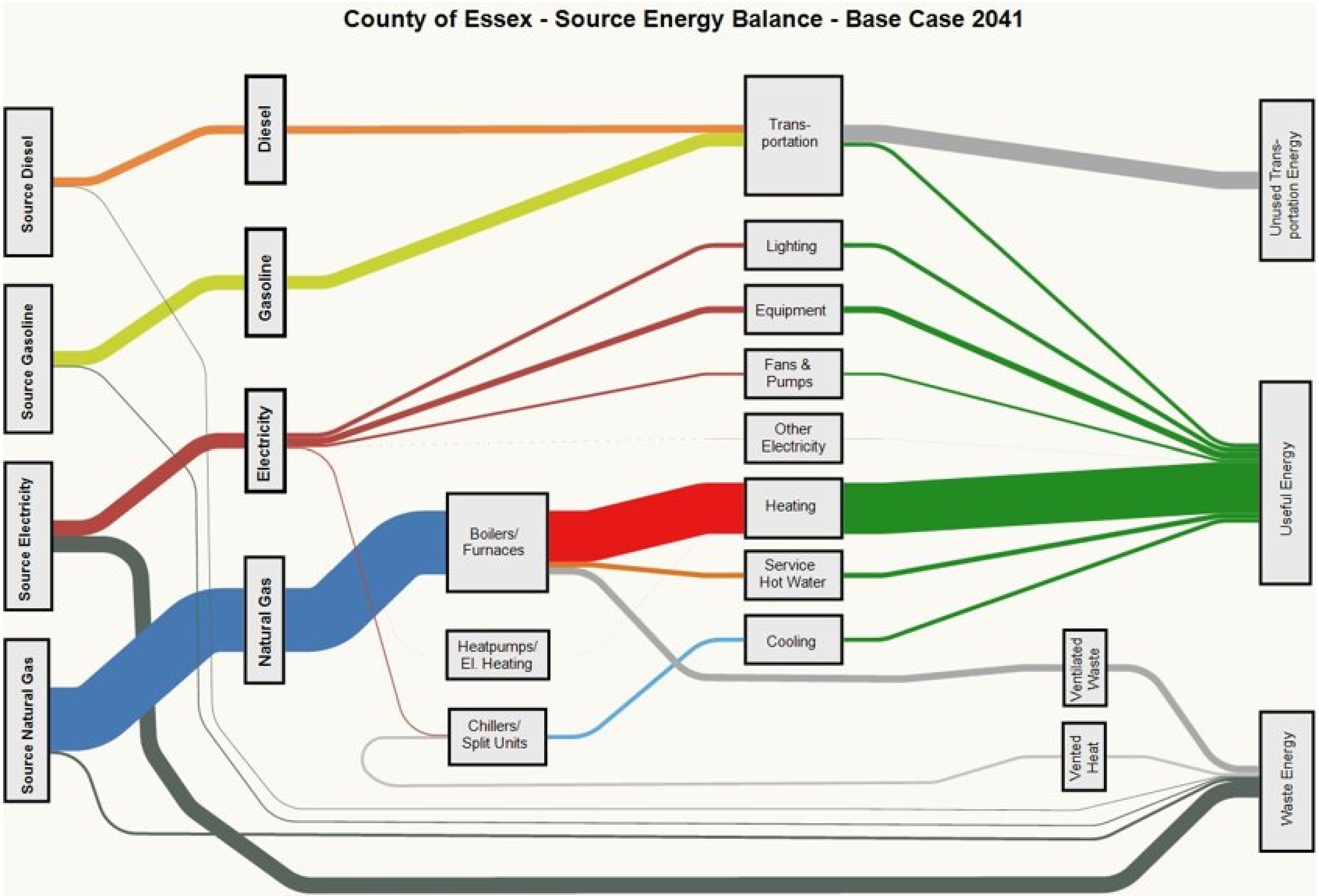

Figure 2b: Essex County Sankey diagram for 2041 Base Case source energy use.

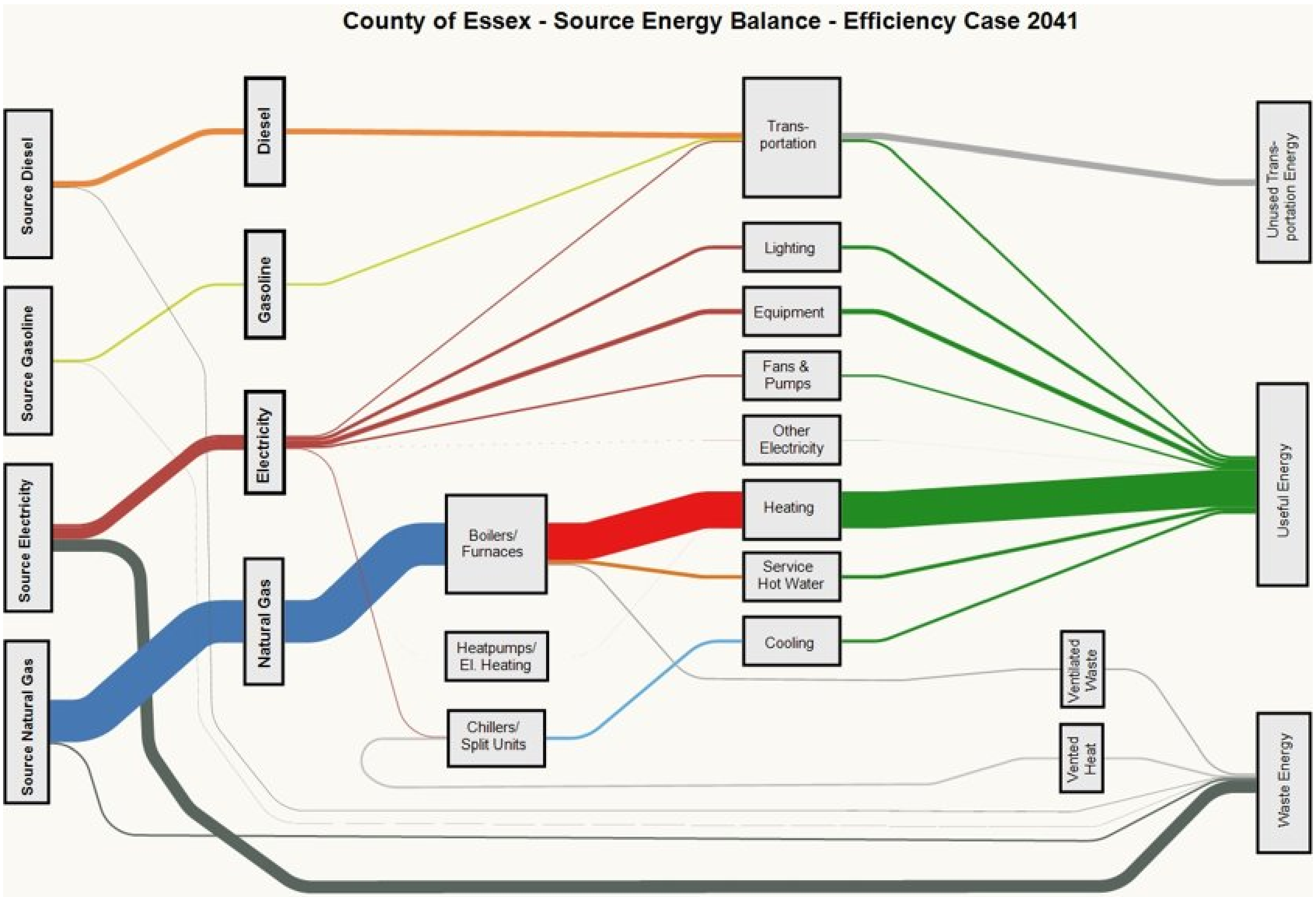

Figure 2c: Essex County Sankey diagram for 2041 REP Efficiency Case source energy use.

10.3.2 GHG Emissions

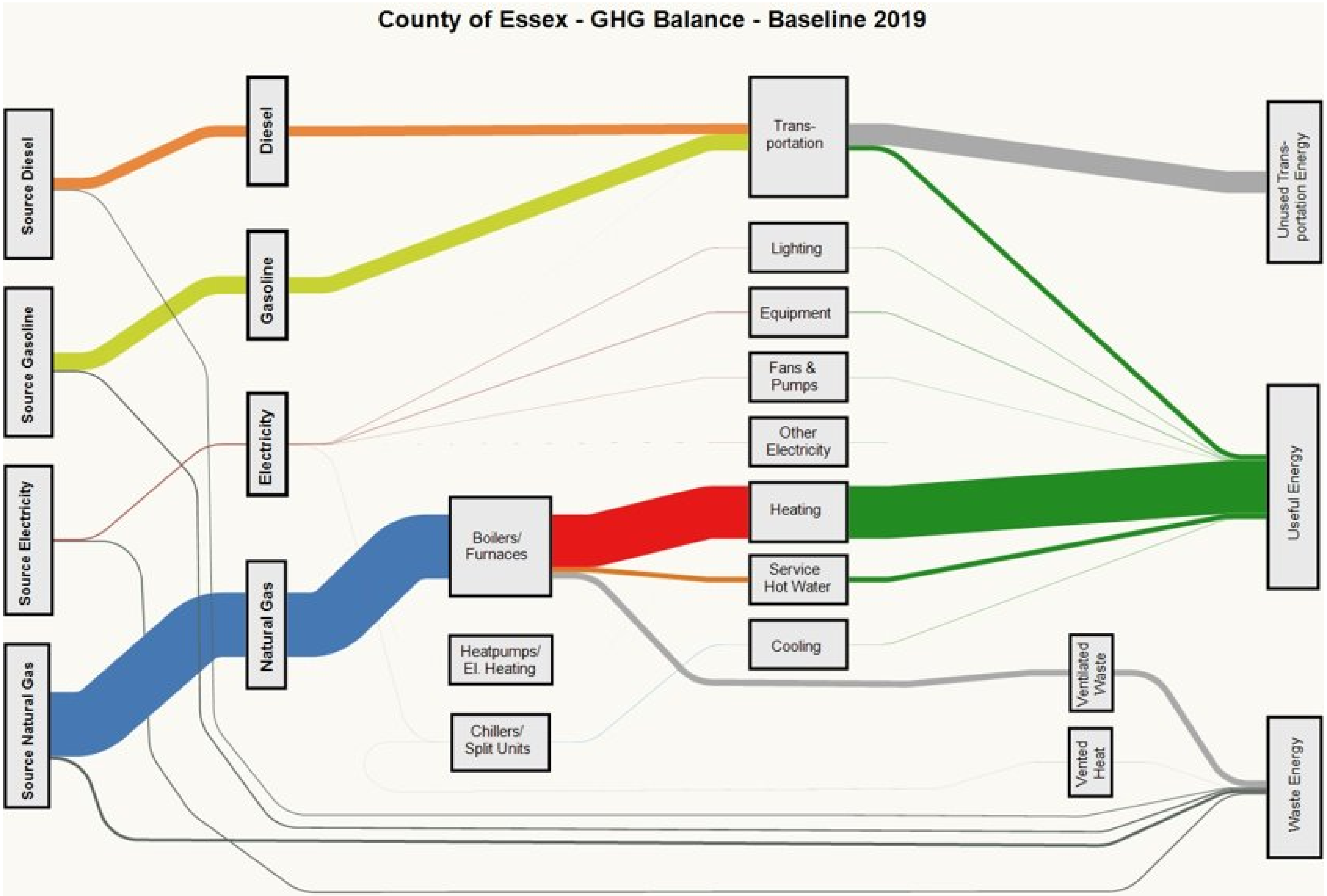

Figure 3a: Essex County Sankey diagram for 2019 Baseline emissions.

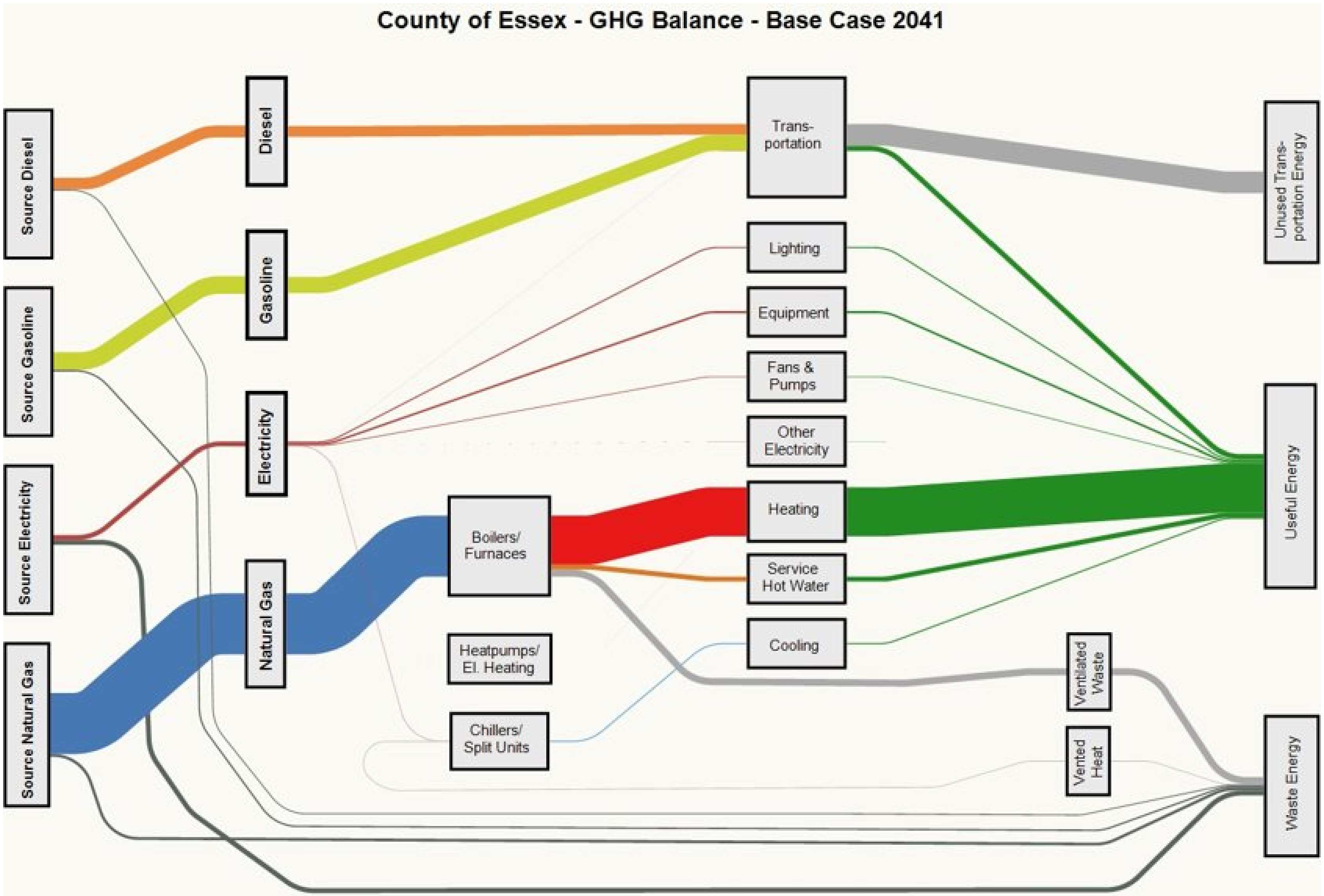

Figure 3b: Essex County Sankey diagram for 2041 Base Case energy emissions.

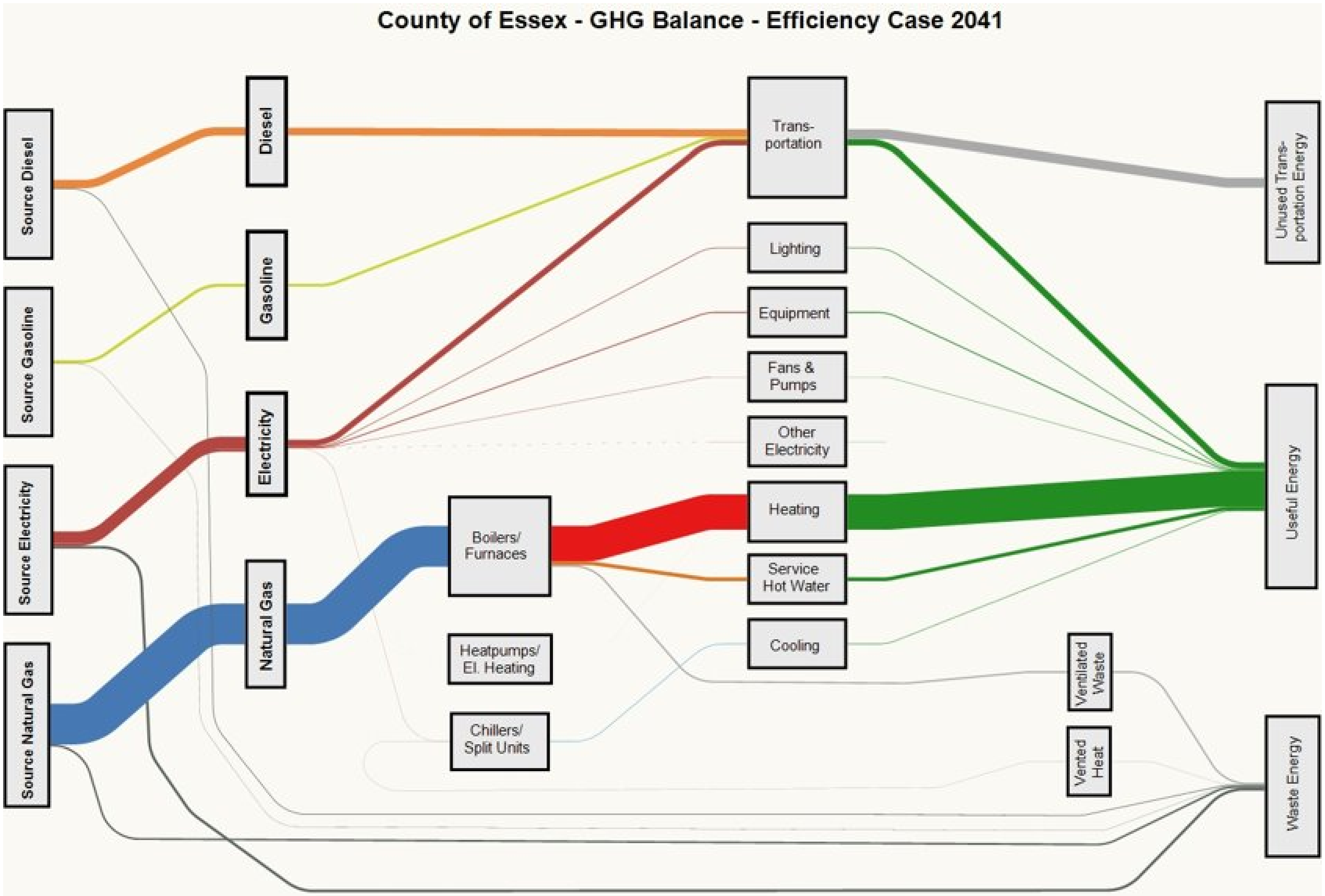

Figure 3c: Essex County Sankey diagram for 2041 REP Efficiency Case for energy emissions.

10.3.3 Energy Costs

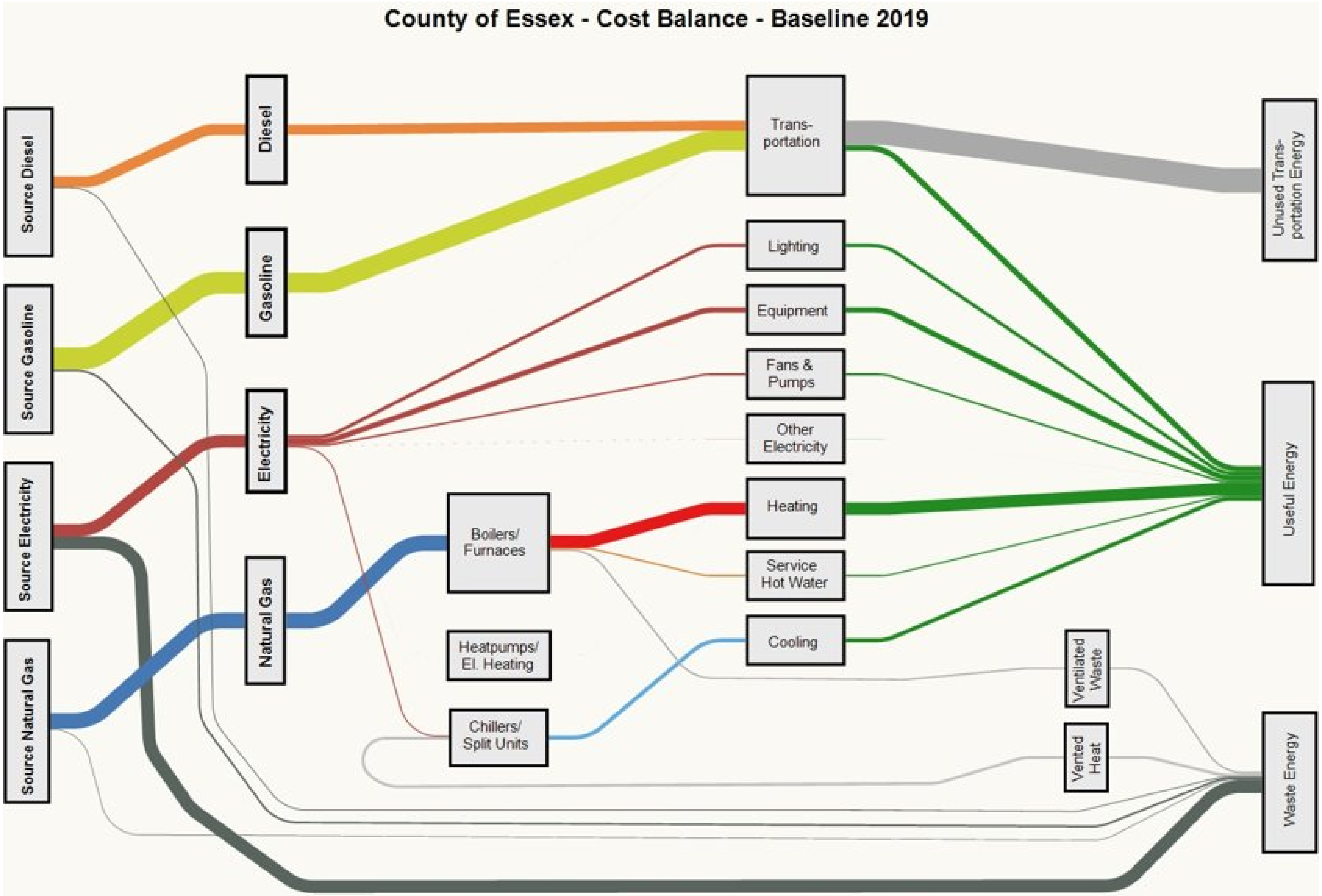

Figure 4a: Essex County Sankey diagram for 2019 Baseline for energy cost.

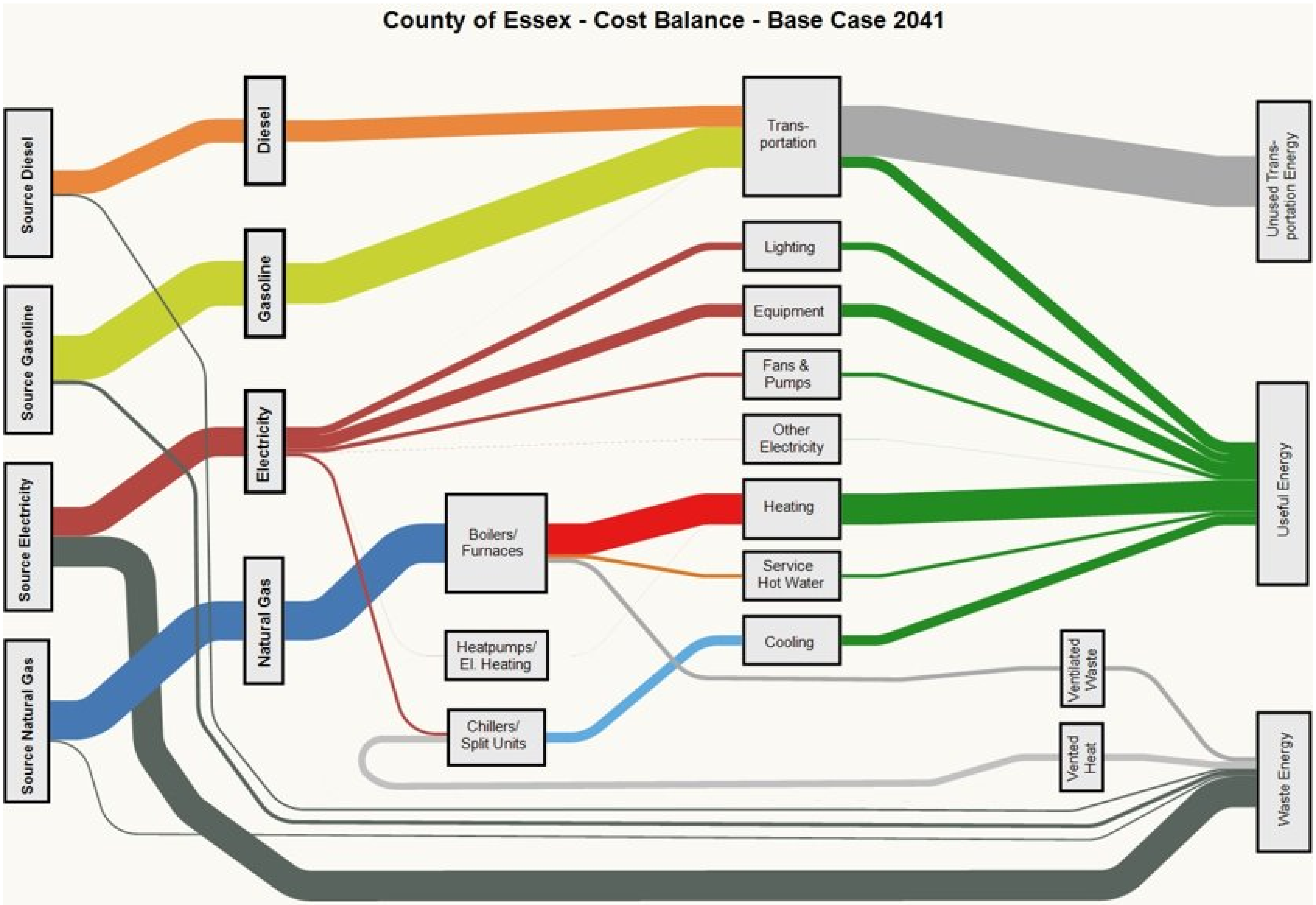

Figure 4b: Essex County Sankey diagram for 2041 Base Case energy costs.

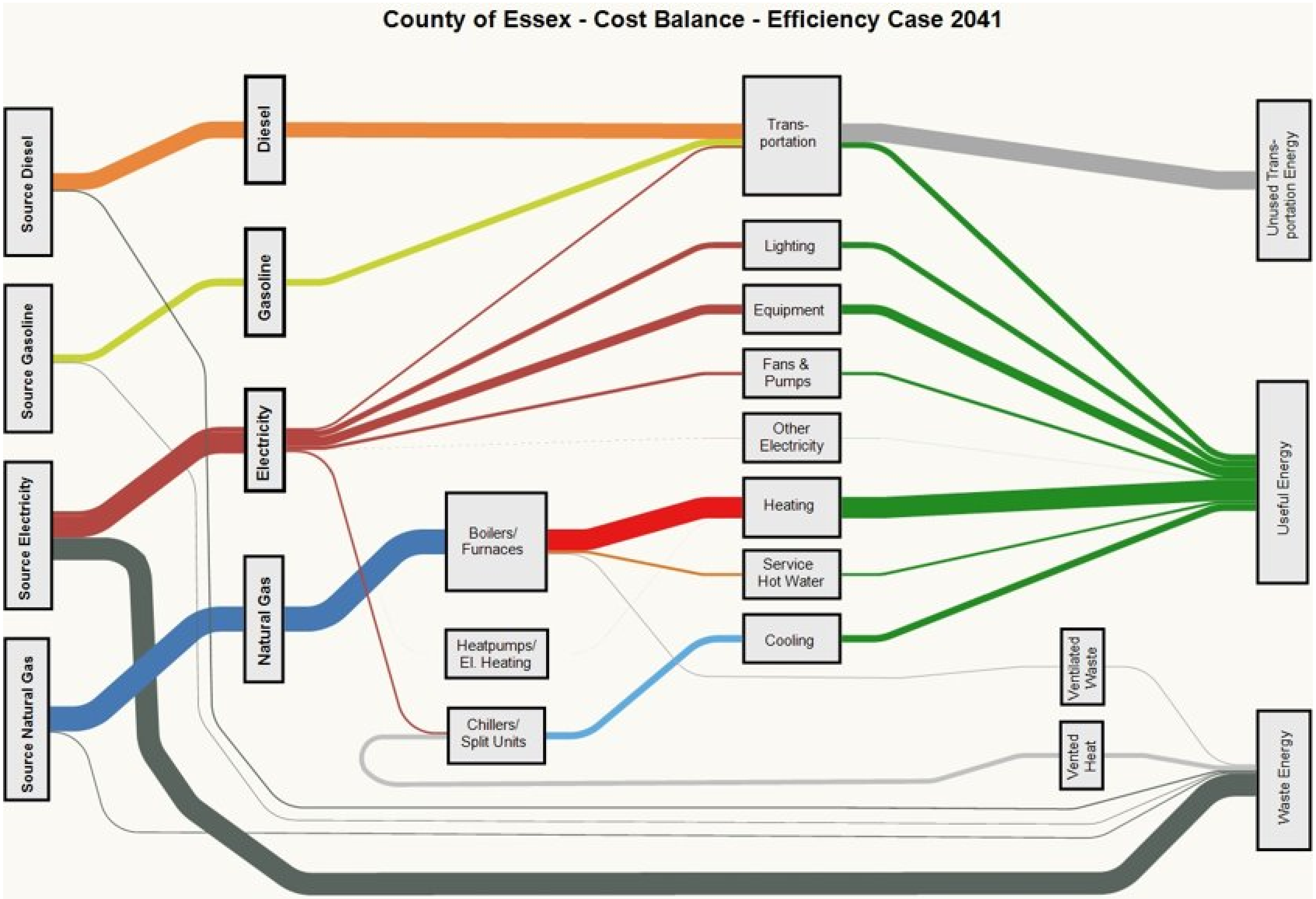

Figure 4c: Essex County Sankey diagram for 2041 REP Efficiency Case for energy costs.