SAP 10 Technical Paper

S10TP-17

Monthly factors for CO_2 emissions and primary energy

Issue 1.0

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DOCUMENT REVISION LOG

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TABLE OF CONTENTS

1. Introduction

SAP 2012 estimates the CO_2 emissions and primary energy (PE) consumption of a dwelling by multiplying calculated delivered energy consumption figures by tabulated CO_2 and PE factors. A single average factor is supplied for each fuel type. In the case of grid electricity, in reality, this factor varies at different times of year and different times of day. This paper describes the SAP 10 method for taking this variation into account, which should give a fairer assessment of technologies that consume or generate electricity.

The figures derived in this paper are intended for use with SAP and SBEM only, and are not intended to be used for other government policies.

2. Method to disaggregate annual factors

The SAP 2012 method to calculate the CO_2 and PE factors for electricity used in SAP takes BEIS predictions as a starting point for the future generation mix from the "Updated energy and emissions projections" publication[1]. This provides a breakdown of the electricity predicted to be produced by each fuel type for a number of future years. CO_2 or PE factors for the individual fuels used for generation can then be applied, along with corrections for international imports and exports, to work out the annual average CO_2 and PE factors for electricity for the applicable years.

However, since BEIS do not provide monthly predictions of the generation mix, the same source cannot be used to look at the variation at different times of year. An investigation into an alternative method of generating monthly CO_2 emission and PE factors based on trends in actual data from previous years was therefore carried out. This makes use of half-hourly generation mix data for the recent past available from Elexon[2] and the University of Sheffield[3]. Using this data, it has been possible to calculate CO_2 and PE

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[1] https://www.gov.uk/government/collections/energy-and-emissions-projections

[2] https://www.bmreports.com/bmrs/?q=generation/fueltype/current

[3] https://www.solar.sheffield.ac.uk/pvlive

factors for grid electricity at any time of year and any time of day, as shown in Figure 1Figure 2 below using data from January 2016 to December 2018.

One acknowledged limitation of this data is that it does not contain generation information relating to Northern Ireland as the data is not available. Due to Northern Ireland's small generation contribution to the UK mix and the current assumption in SAP that all parts of the UK have the same CO_2 and PE factors, this is considered to lead to only a minor error. It is intended that this will be incorporated in the future if the data becomes available.

The analysis of this data is described below. It focuses initially on CO_2 emission factors, but the same principles apply to PE factors.

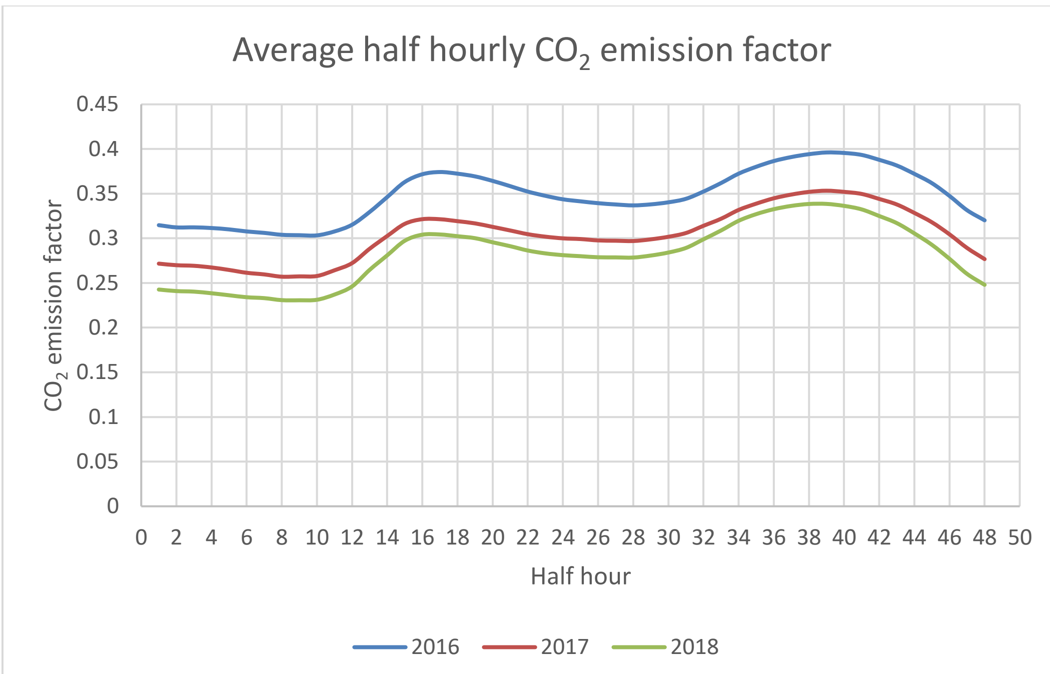

Figure 1 Average half hourly CO_2 emission factor

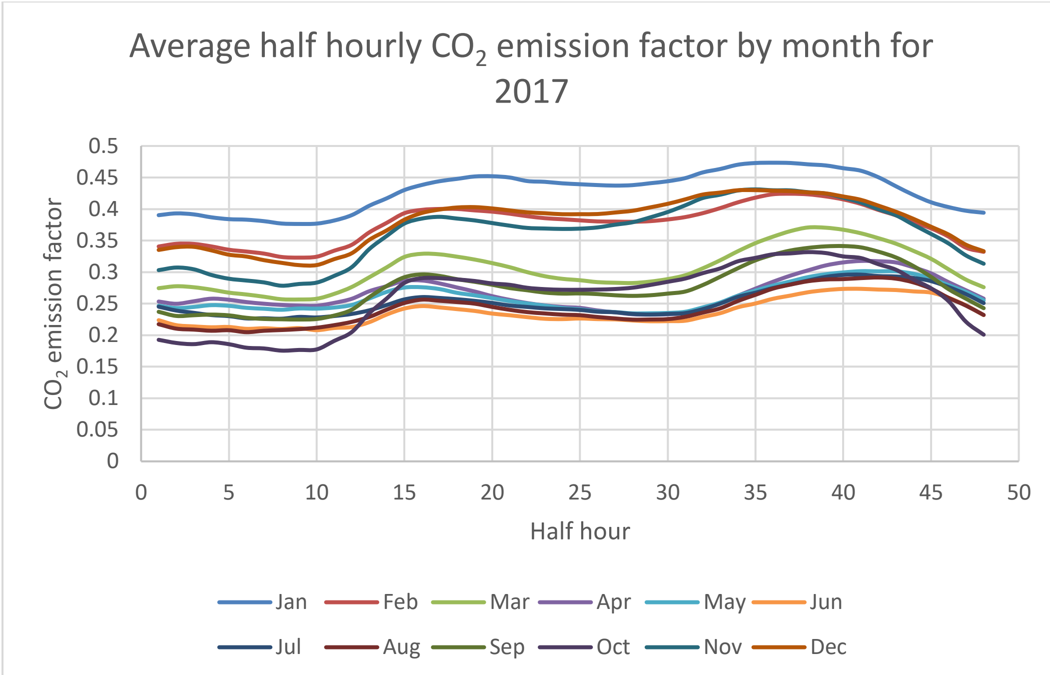

Figure 2 Average half hourly CO_2 emission factor by month for 2017

Figure 1 shows how the average CO_2 emission factor varies over the course of a day for the last three years. The general trend for each year is the same, varying throughout the day in response to the demand on the electricity grid; but this has been shifting lower each year, reflecting the decreasing annual CO_2 emission factor.

Figure 2 shows the 2017 data broken down by month[4]. Here the winter months can be seen to have a higher CO_2 emission factor, presumably because electricity demand is higher and therefore more non-renewable generation is used. However, it can be seen that the general trend remains similar in each month.

[4] 2017 was used because it has the most complete data set

3. Factor multipliers

On the basis that the variation across months and hours of the day is similar and fairly predictable over the 3 years for which data is available, these patterns were used to estimate future CO_2 emission factors at the same level of granularity. The method uses two sets of “factor multipliers” relating the CO_2 emission factor at a particular point in the year to the annual average CO_2 emission factor for that year. One set varies the factor with time of day and the other varies it according to the month of the year.

The main limitation of this approach is that the average of (recent) past data is applied to an annual figure predicted for a few years in the future. In practice any significant change in the fuel mix in that time will have an impact on the variation over the months and hours of the day.

3.1 Time-of-day multiplier

In the case of a time-of-day multiplier, the three years of measured data provide over 1000 days of data points (at half-hourly resolution), so a reliable average can be formed. This was derived by calculating the ratio of the factor for each half-hour to the annual average CO_2 emission factor for the year and then averaging over all days. This process was repeated for PE – both are shown in Figure 3.

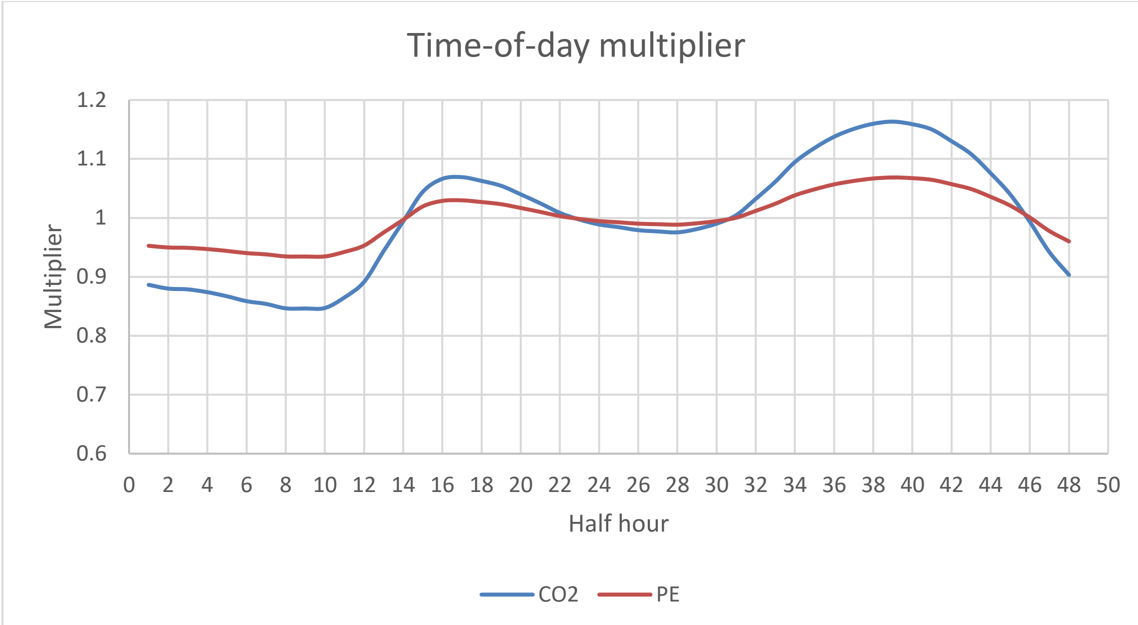

Figure 3: Time-of-day multiplier

3.2 Monthly multiplier

For the monthly multiplier, the derivation is based on three data points for each month[5]. The natural variability in the weather means that calculating the average factor for each month directly from the data could be unreliable – e.g. the UK may have had three unusually warm Februaries. A method to weather-correct the data was therefore employed. This involved finding the relationship between air temperature and CO_2 emission factor, then applying this to SAP's average monthly air temperatures to produce a normalised CO_2 emission factor for each month. First, actual monthly air temperatures[6] were compared to monthly electricity demand, as shown in Figure 4. Figure 5 then plots the CO_2 emission factor against electricity demand. Lower air temperatures can be seen to correlate with increased electricity demand and greater electricity demands with higher CO_2 emission factors.

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[5] i.e. one per year.

[6] https://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Tmean/date/Midlands.txt

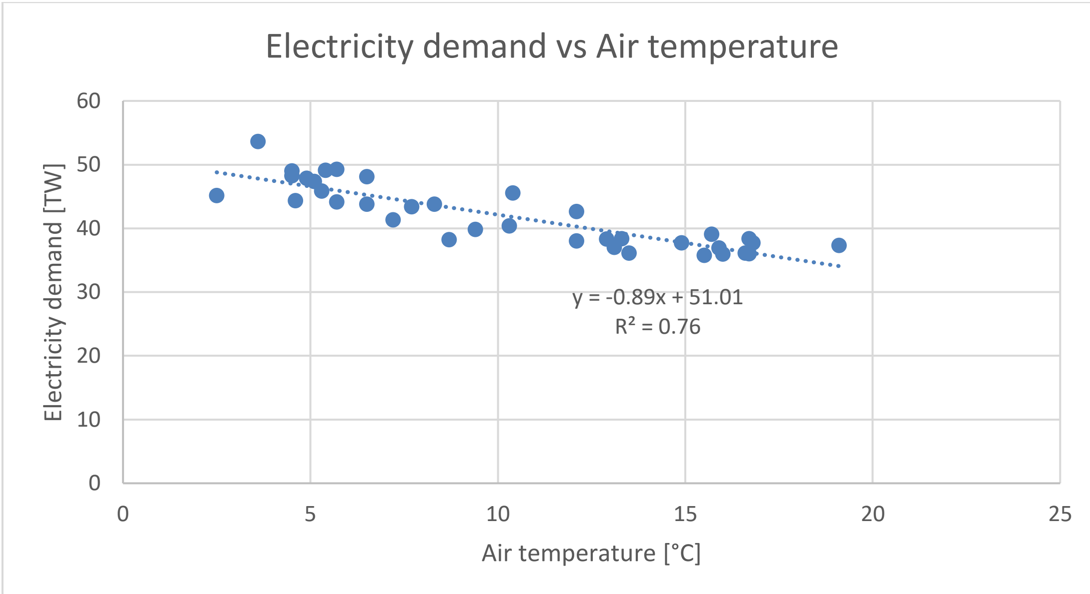

Figure 4: Electricity demand vs Air temperature

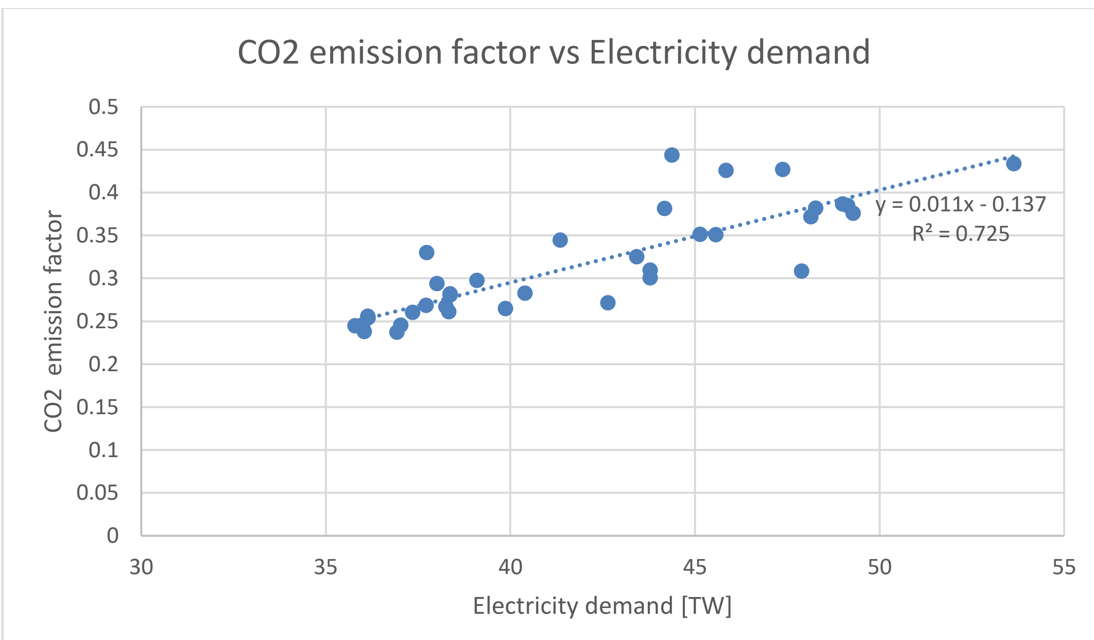

Figure 5: CO_2 emission factor vs Electricity demand

Figure 5 shows a larger degree of scatter than Figure 4, but a positive correlation is still clear. For this analysis, a linear relationship has been assumed. Given the scatter present, a power curve and 2nd order polynomial line were also tried, but these both were very close to linear. The rate of increase of CO_2 emission factor with electricity demand would presumably flatten off at very high demands (since it could not exceed the CO_2 factor for electricity generated by a coal power station) and very low demands (since the entire demand would be met using nuclear and renewables). However, in the range covered by the data, a linear fit was deemed to be suitable, albeit with some uncertainty due to the scatter.

Combining the relationships from Figure 4 and Figure 5 provides a linear relationship[7] between air temperature and the monthly CO_2 emission factor. Applying this to SAP's average monthly air temperatures results in a weather-corrected set of monthly CO_2 emission multipliers for application in SAP 10. The same process was used to produce a set of monthly PE multipliers; both are plotted in Figure 6.

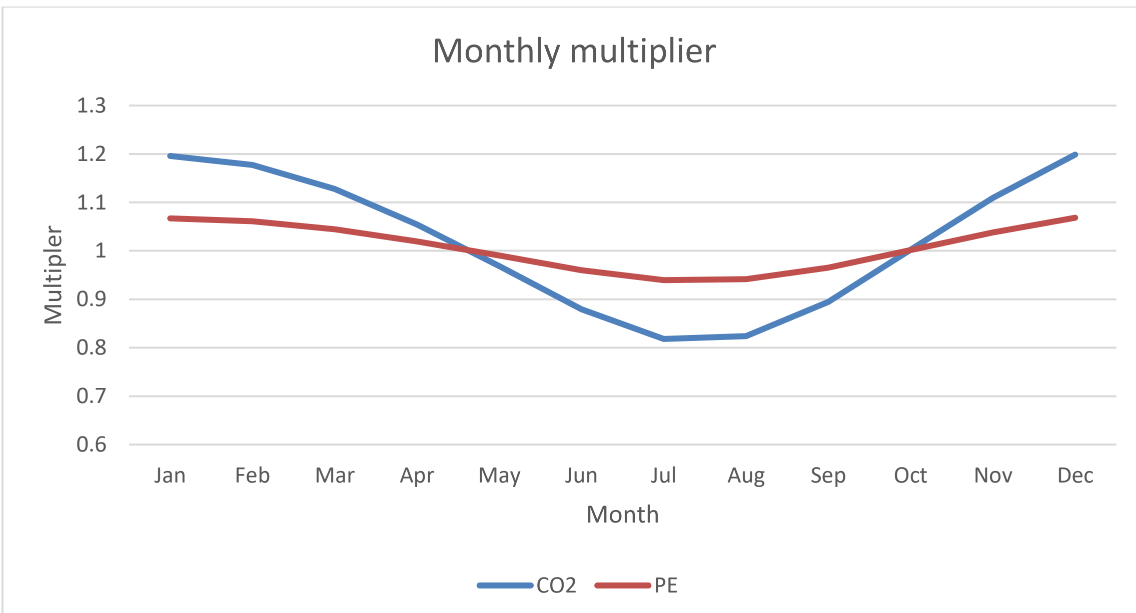

Figure 6: Monthly multiplier

[7] Electricity demand = 51.01 – 0.89 x Air temperature

CO_2 emission factor = 0.011 x Electricity demand – 0.137

Therefore CO_2 emission factor = 0.424 – (0.00979 × Air temperature)

The graphs show that the variation in the CO_2 emission multiplier over the year, at around ±20%, is much higher than the variation for the PE multiplier, at around ±7%. This is because the differences in the CO_2 emission factors of the fuels that are used to generate electricity are proportionately much larger than the differences in their PE factors.

For comparison, Figure 7 shows the monthly CO_2 emission factor for each of the last three years superimposed on the results from using the monthly multiplier applied to the average annual CO_2 emission factor for the same years. As can be seen, the predicted CO_2 emission factor produced by the multiplier method removes the weather related 'noise' from the data while maintaining the same overall trend.

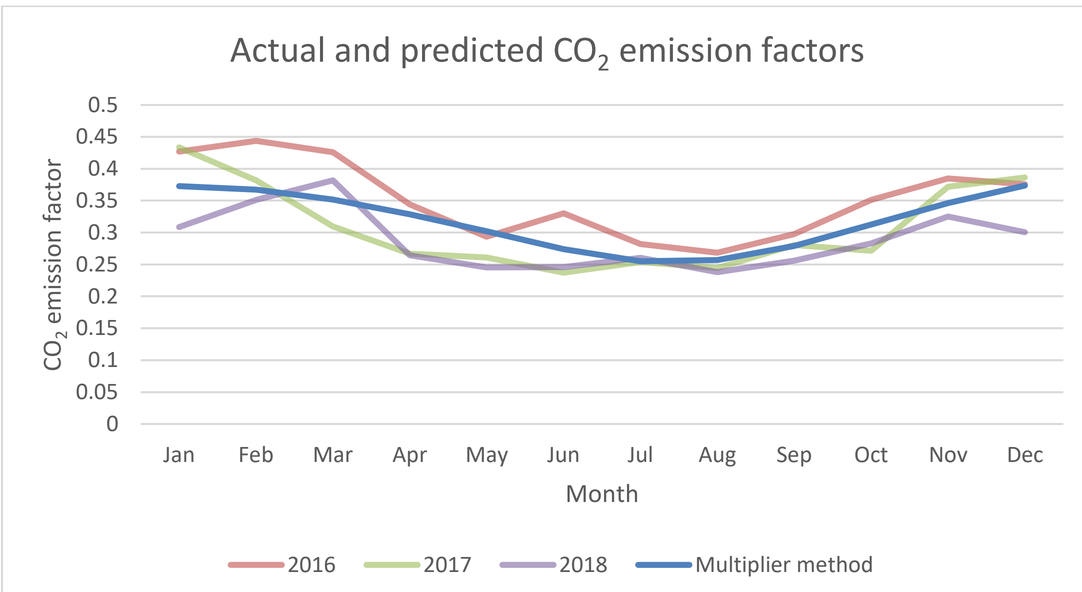

Figure 7: Actual and predicted CO_2 emission factors

4. Implementation in SAP 10

Using these multipliers, Table 12 of the SAP 10 specification document could potentially be extended with a set of CO_2 emission and PE factors for electricity for each half hour of each month, as shown in the Appendix. However, to avoid the table becoming unmanageably large and complicating the SAP methodology (by requiring estimated half-hourly consumption for all uses of electricity), the existing electricity tariff categories have been maintained showing the annual factors. These are then broken down by month using monthly multipliers presented in separate tables (Tables 12d and 12e), as has been done in generating the figures shown in Table 1 below. For each tariff, an average of the applicable period was taken to give the monthly CO_2 emission and PE factors. For example, the standard tariff takes an average of every half hour for each month, but the 7-hour low rate tariff takes an average of the 7 hours when the low rate is applicable.

The following assumptions have been used for the tariff hour allocations. In practice these can vary from supplier to supplier, however these ranges represent reasonable averages:

7-hour: 00:00 – 07:00 for low rate, 07:00 – 00:00 for high rate
10-hour: 00:00 – 05:00, 13:00 – 16:00 and 20:00 – 22:00 for low rate, high rate at other times
Other tariffs: standard factors for all tariffs as there is inconclusive evidence of which hours could be considered typical

Table 1 and Table *2* are taken from the SAP 10.2 specification document, Tables 12d and 12e.

Table 1 Monthly CO2 emission factors for electricity

CO_2 emission factor [$kgCO_2e/kWh$]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
standard tariff	0.187	0.184	0.176	0.164	0.151	0.137	0.128	0.129	0.140	0.156	0.173	0.187
7-hour tariff (high rate)	0.196	0.193	0.185	0.173	0.158	0.144	0.134	0.135	0.146	0.164	0.182	0.196
7-hour tariff (low rate)	0.164	0.162	0.155	0.145	0.133	0.121	0.112	0.113	0.123	0.138	0.152	0.165
10-hour (high rate)	0.193	0.19	0.182	0.17	0.156	0.142	0.132	0.133	0.144	0.162	0.179	0.193
10-hour (low rate)	0.178	0.175	0.168	0.157	0.144	0.131	0.122	0.123	0.133	0.149	0.165	0.178
18-hour (high rate)	0.187	0.184	0.176	0.164	0.151	0.137	0.128	0.129	0.140	0.156	0.173	0.187
18-hour (low rate)	0.187	0.184	0.176	0.164	0.151	0.137	0.128	0.129	0.140	0.156	0.173	0.187
24-hour heating tariff	0.187	0.184	0.176	0.164	0.151	0.137	0.128	0.129	0.140	0.156	0.173	0.187
electricity sold to grid, PV	0.225	0.218	0.201	0.175	0.148	0.122	0.105	0.107	0.126	0.158	0.194	0.226
electricity sold to grid, other	0.187	0.184	0.176	0.164	0.151	0.137	0.128	0.129	0.140	0.156	0.173	0.187
electricity displaced from grid, PV	0.225	0.218	0.201	0.175	0.148	0.122	0.105	0.107	0.126	0.158	0.194	0.187
electricity displaced from grid, other	0.187	0.184	0.176	0.164	0.151	0.122	0.128	0.129	0.140	0.156	0.173	0.226
electricity, any tariff	0.187	0.184	0.176	0.164	0.151	0.122	0.128	0.129	0.140	0.156	0.173	0.187

Table 2 Monthly primary energy factors for electricity

Primary energy factor [kWh/kWh]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
standard tariff	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
7-hour tariff (high rate)	1.709	1.699	1.673	1.633	1.586	1.538	1.505	1.508	1.546	1.605	1.663	1.711
7-hour tariff (low rate)	1.590	1.581	1.556	1.519	1.475	1.430	1.400	1.403	1.438	1.492	1.547	1.591
10-hour (high rate)	1.698	1.688	1.662	1.622	1.576	1.528	1.495	1.498	1.536	1.594	1.652	1.700
10-hour (low rate)	1.642	1.632	1.607	1.568	1.523	1.477	1.445	1.448	1.485	1.541	1.597	1.643
18-hour (high rate)	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
18-hour (low rate)	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
24-hour heating tariff	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
electricity sold to grid, PV	1.793	1.774	1.719	1.638	1.545	1.452	1.390	1.397	1.469	1.581	1.697	1.795
electricity sold to grid, other	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
electricity displaced from grid, PV	1.793	1.774	1.719	1.638	1.545	1.452	1.390	1.397	1.469	1.581	1.697	1.795
electricity displaced from grid, other	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676
electricity, any tariff	1.675	1.665	1.639	1.600	1.554	1.507	1.474	1.477	1.515	1.572	1.629	1.676

By averaging each half hour, the method assumes that electricity use is constant throughout the time period applicable for each tariff. To account for the daily variability in use, an electricity demand-based weighting for each half hour was explored. However, this multiplier was found to add considerable complication owing to the dynamic site-specific and heating-type-specific nature of heat demand. For example, the electricity demand at each hour of the day of a home heated by an electric heat pump would depend on the output of the heat pump, relative to the heat loss of the home. Therefore, as long as SAP is a monthly calculation, it is not practical to attempt to differentiate in this way, other than between the on-peak and off-peak proportions (which SAP already estimates).

An exception to this is PV generation which has a predictable profile across an average day in each month. Therefore, extra rows have been added ('electricity sold to grid, PV' and 'electricity displaced from grid, PV') to be used for the calculation of the CO_2 emissions and PE offset by PV[8]. This was calculated by taking an average of the half-hourly factors weighted by the average solar radiation during each half hour, resulting in a modified profile for each month of the year.

5. Implications

Electric heating

In SAP 2012, the CO_2 emissions associated with electric heating are calculated to be the energy used by the heating system multiplied by the annual electricity CO_2 emission factor. As this CO_2 emission factor is an average for the whole year, it gives equal weight to the lower factor during the summer months and the higher factor during the winter months. With the new SAP 10 method, the usage in each month is multiplied by the factor in the applicable month, before the annual total is summed. For homes with electric heating, as the CO_2 emission factor will be greatest in the winter months, CO_2 emissions will tend to be higher.

For off-peak heating tariffs this is counteracted by the time-of-day multiplier. For example, a 7-hour tariff will typically be used with storage heaters such that electricity demand will occur during the night when the CO_2 emission factor is lower. Examples are presented below to show how this would impact the CO_2 emissions and PE for a typical new dwelling

[8] The differentiation between 'displaced from grid' and 'sold to grid' is only needed to allow for the fact that different fuel prices are allocated to calculate the savings.

with different electric heating systems[9]. For comparison, the results using a typical gas boiler are also given.

Table 3 Impact of proposed changes

Heating configuration	**SAP 2012 (annual ave. factors)**		**SAP 10 (monthly factors)**	
	Total CO2 emissions [kg]	**Total primary energy [kWh]**	**Total CO2 emissions [kg]**	**Total primary energy [kWh]**
Standard tariff Space heating: panel heaters Water heating: elec immersion	895.6	9332.2	988.1 (+9.4%)	9332.2 (+3.5%)
7-hour tariff Space heating: storage heaters Water heating: elec immersion	1017.1	10229.4	993.1 (-2.4 %)	10079.0 (-1.5%)
Mains gas Space heating: combi boiler Water heating: combi boiler	1540.6	8332.5	1540.6	8332.5

These examples show that, where electric panel heaters are used, CO_2 emissions and PE will increase under the proposed method due to the increased weighting given to higher winter factors. For storage heaters, the CO_2 emissions have decreased slightly. Here, two opposing effects are at play, with higher factors during the winter, but lower factors during the night, which almost balance each other. The effect on PE is similar. When compared

[9] The same dwelling is used for each example – only the heating system is varied; however, space and water heating demand is dependent on the heating technology used and is therefore different for each scenario.

to a gas boiler, both technologies are calculated to produce lower CO_2 emissions but use more PE.

Heat pump examples

The examples below show the total CO_2 emissions and PE calculated for two example heat pumps installed in the same example dwelling as the previous examples. It is assumed the heat pump provides both space and hot water heating and uses efficiency figures taken from the Product Characteristics Database (PCDB)[10]. The impact of using monthly CO_2 emission and PE factors on the standard tariff is similar to electric panel heaters, due to the increased weighting towards the winter months.

All versions of SAP to date utilise an annual efficiency value for heat pumps, whether using default heat pump data or efficiency estimates held in the PCDB. In practice, with the adoption of monthly CO_2 emission and PE factors, it would be appropriate to consider using monthly efficiencies for heat pumps too. However, such a change would require the PCDB to hold 12 times as much data, causing an increase in PCDB administration burden for BRE and additional work for SAP software providers. BRE therefore undertook analysis to determine the impact of adopting monthly heat pump efficiencies, which tend to be poorer in winter months. The table below demonstrates the impact of applying monthly heat pump efficiencies to the monthly heating energy requirement for the example dwelling. The difference in results between using annual and monthly efficiencies is less than 1.5%. Weighing up this small difference against the added complexity of moving to monthly heat pump efficiencies, BRE and BEIS decided that annual heat pump efficiencies should continue to be used.

Consideration was given to the compromise of applying a fixed heat pump efficiency adjustment profile to approximately allow for this variation in heat pump efficiency without complicating the PCDB entry. However, the profile would vary significantly from case to

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[10] Calculated using: "Calculation Method: CALCM:01 SAP REVISED HEAT PUMP PERFORMANCE METHOD, Issue 1.2" - http://www.ncm-pcdb.org.uk/sap/filelibrary/pdf/Calculation_Methodology/SAP_2012/CALCM-01---SAP-REVISED-HEAT-PUMP-PERFORMANCE-METHOD---V1.2.pdf

case. For example, it would look quite different in a home where hot water is the dominant load, compared to a home where space heating dominates. Therefore, this was deemed to not be a helpful refinement.

Table 4 Impact on heat pumps

Heat pump model[11]	**SAP 2012 (annual factors)**		**SAP 10 (monthly factors)**	
	Total CO2 emissions [kg]	**Total primary energy [kWh]**	**Total CO2 emissions [kg]**	**Total primary energy [kWh]**
Heat Pump - 35°C design flow temperature	398.6	4008.7	434.5 (+8.26%)	4135.3 (+3.1%)
Heat Pump - 55°C design flow temperature	476.4	4791.6	523.1 (+8.9%)	4955.9 (+3.3%)

<u>Combined heat and power (CHP) example</u>

Another technology type of interest is CHP, which is typically installed as part of a heat network. The example below shows the results for this scenario.

Table 5 Impact on CHP

Heating configuration	**SAP 2012 (annual factors)**		**SAP 10 (monthly factors)**	
	Total CO2 emissions [kg]	**Total primary energy [kWh]**	**Total CO2 emissions [kg]**	**Total primary energy [kWh]**
Heat network with CHP heat source	2531.5	10542.6	2374.7 (-2.4%)	10342.9 (-1.9%)

[11] Two heat pump examples are based on the same product model, an air source heat pump, but with a design flow temperature of 35°C and 55°C.

The electricity produced by CHP is given credit in SAP by multiplying the amount generated by the electricity CO_2 emission and PE factors. The amount of electricity produced by CHP is assumed in SAP to be proportional to the amount of heat produced therefore this is greatest in the winter months. Since this is when the CO_2 emission and PE factors are highest, the benefit of electricity generation is increased under the updated method and so the total CO_2 emissions and PE both decrease as a result of using monthly factors.

Photovoltaics example

The example below shows the impact that the change has on the benefits of a PV installation. Electricity generated by PV is greatest in the summer, when the CO_2 emission factor of the grid is lowest, so the savings from exporting at this time of year are decreased. On the other hand, there is a benefit in some months related to the fact that PV energy is generated during the day. However, this is not sufficient to offset the previous effect, so the overall impact of moving to monthly factors is to reduce the savings from PV.

Table 6 Impact on PV

	Current (annual factors)		**Proposed (monthly factors)**	
	Total CO2 saving [kg]	**Total primary energy saving [kWh]**	**Total CO2 saving [kg]**	**Total primary energy saving [kWh]**
Photovoltaics, 3kWp	399.8	4021.3	365.6 (-9.4%)	3899.9 (-3.1%)

6. Conclusions

Feedback has been received suggesting it is incorrect for SAP to attribute annual average CO_2 emission and PE factors to electricity demands/provisions which are not evenly distributed across the year or day. Since BEIS does not publish monthly or half-hourly predictions of the generation mix which would recognise this variation, a method has been developed for using multipliers based on data for the recent past to estimate monthly half-hourly CO_2 emission and PE factors from annual averages for future years. By averaging applicable hours for each tariff type, a derivation of approximate monthly average factors appropriate for each tariff type have been made which should give a fairer comparison between different electricity consuming and generating technologies. This provides a workable solution for use in SAP 10 and has been implemented by the addition of two extra SAP reference tables and minor modifications to the ‘SAP worksheet’.

A limitation of this method is that the proposed multipliers are based on usage in the past three years. In the future, these trends may change, for example due to increasing renewable generation or greater electric vehicle usage and will therefore be updated regularly.

Examples looking at the impact of moving to monthly factors on some key technologies showed that:

- CO_2 emissions and PE are higher for direct electric heating
- CO_2 emissions and PE are slightly lower for electric storage heaters
- CO_2 emissions and PE are higher for heat pumps
- CO_2 emissions and PE are slightly lower for CHP systems
- CO_2 emissions and PE savings from PV generation are reduced

Appendix

The table below shows the full set of CO_2 emission factors for each half hour in each month based on the proposed SAP 10.2 CO_2 emission factor.

SAP 10.1 Carbon f		Month											
0.156		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	0.16533	0.16278	0.15599	0.1458	0.13392	0.12161	0.11312	0.11397	0.12373	0.13859	0.15344	0.16575
	2	0.16415	0.16162	0.15487	0.14476	0.13296	0.12074	0.11231	0.11315	0.12285	0.1376	0.15235	0.16457
	3	0.1639	0.16137	0.15464	0.14454	0.13276	0.12056	0.11214	0.11298	0.12266	0.13739	0.15211	0.16432
	4	0.16301	0.1605	0.1538	0.14376	0.13204	0.1199	0.11153	0.11237	0.122	0.13664	0.15129	0.16343
	5	0.16171	0.15922	0.15257	0.14261	0.13099	0.11895	0.11064	0.11147	0.12102	0.13555	0.15008	0.16212
	6	0.16017	0.1577	0.15112	0.14125	0.12974	0.11782	0.10959	0.11041	0.11987	0.13426	0.14866	0.16058
	7	0.15929	0.15683	0.15029	0.14048	0.12903	0.11717	0.10899	0.10981	0.11921	0.13352	0.14784	0.1597
	8	0.15789	0.15546	0.14898	0.13925	0.1279	0.11614	0.10804	0.10885	0.11817	0.13236	0.14654	0.1583
	9	0.15785	0.15542	0.14893	0.13921	0.12786	0.11611	0.108	0.10881	0.11814	0.13232	0.1465	0.15825
	10	0.15801	0.15558	0.14909	0.13935	0.12799	0.11623	0.10811	0.10893	0.11826	0.13245	0.14665	0.15842
	11	0.16134	0.15885	0.15223	0.14229	0.13069	0.11868	0.11039	0.11122	0.12075	0.13524	0.14974	0.16175
	12	0.16625	0.16369	0.15686	0.14661	0.13466	0.12229	0.11375	0.1146	0.12442	0.13936	0.1543	0.16667
	13	0.17601	0.1733	0.16607	0.15522	0.14257	0.12947	0.12043	0.12133	0.13173	0.14754	0.16336	0.17646
	14	0.18541	0.18256	0.17494	0.16352	0.15019	0.13638	0.12686	0.12782	0.13876	0.15542	0.17208	0.18589
	15	0.19475	0.19175	0.18375	0.17175	0.15776	0.14326	0.13326	0.13426	0.14576	0.16326	0.18075	0.19525
	16	0.19887	0.19581	0.18764	0.17539	0.16109	0.14629	0.13607	0.1371	0.14884	0.16671	0.18458	0.19938
	17	0.1994	0.19633	0.18814	0.17586	0.16152	0.14668	0.13644	0.13746	0.14924	0.16715	0.18507	0.19992
	18	0.19821	0.19516	0.18702	0.1748	0.16056	0.1458	0.13562	0.13664	0.14834	0.16615	0.18396	0.19872
	19	0.19666	0.19364	0.18556	0.17344	0.1593	0.14466	0.13456	0.13557	0.14718	0.16486	0.18253	0.19717
	20	0.19397	0.19098	0.18301	0.17106	0.15712	0.14268	0.13272	0.13371	0.14517	0.16259	0.18002	0.19446
	21	0.19113	0.18818	0.18033	0.16855	0.15482	0.14059	0.13077	0.13175	0.14304	0.16021	0.17739	0.19162
	22	0.18811	0.18521	0.17749	0.1659	0.15237	0.13837	0.12871	0.12968	0.14078	0.15769	0.17459	0.18859
	23	0.18598	0.18311	0.17548	0.16402	0.15065	0.1368	0.12725	0.12821	0.13919	0.1559	0.17261	0.18646
Half hour	24	0.18443	0.18159	0.17401	0.16265	0.14939	0.13566	0.12619	0.12714	0.13803	0.1546	0.17117	0.1849
	25	0.18358	0.18075	0.17321	0.1619	0.14871	0.13504	0.12561	0.12655	0.13739	0.15389	0.17039	0.18405
	26	0.18263	0.17982	0.17232	0.16106	0.14794	0.13434	0.12496	0.1259	0.13668	0.15309	0.1695	0.1831
	27	0.18224	0.17943	0.17195	0.16072	0.14762	0.13405	0.12469	0.12563	0.13639	0.15277	0.16914	0.18271
	28	0.18194	0.17914	0.17167	0.16046	0.14738	0.13383	0.12449	0.12542	0.13617	0.15251	0.16886	0.18241
	29	0.18298	0.18017	0.17265	0.16138	0.14822	0.1346	0.1252	0.12614	0.13695	0.15339	0.16983	0.18345
	30	0.18469	0.18185	0.17426	0.16288	0.14961	0.13585	0.12637	0.12732	0.13823	0.15482	0.17142	0.18517
	31	0.18734	0.18445	0.17676	0.16522	0.15175	0.1378	0.12818	0.12914	0.14021	0.15704	0.17387	0.18782
	32	0.19251	0.18954	0.18164	0.16977	0.15594	0.1416	0.13172	0.13271	0.14407	0.16137	0.17867	0.193
	33	0.19794	0.19489	0.18676	0.17457	0.16034	0.1456	0.13544	0.13645	0.14814	0.16593	0.18371	0.19845
	34	0.20416	0.20102	0.19263	0.18005	0.16538	0.15018	0.13969	0.14074	0.1528	0.17114	0.18949	0.20469
	35	0.20859	0.20538	0.19681	0.18396	0.16897	0.15344	0.14273	0.1438	0.15611	0.17486	0.1936	0.20913
	36	0.21217	0.2089	0.20019	0.18711	0.17186	0.15607	0.14517	0.14626	0.15879	0.17785	0.19692	0.21271
	37	0.21464	0.21133	0.20252	0.18929	0.17386	0.15788	0.14686	0.14796	0.16064	0.17992	0.19921	0.21519
	38	0.21629	0.21296	0.20408	0.19075	0.1752	0.1591	0.14799	0.1491	0.16188	0.18131	0.20075	0.21685
	39	0.21696	0.21362	0.20471	0.19134	0.17575	0.15959	0.14845	0.14957	0.16238	0.18187	0.20137	0.21752
	40	0.21616	0.21283	0.20395	0.19063	0.17509	0.159	0.1479	0.14901	0.16177	0.1812	0.20062	0.21671
	41	0.21447	0.21117	0.20236	0.18914	0.17373	0.15776	0.14675	0.14785	0.16051	0.17978	0.19906	0.21502
	42	0.21079	0.20754	0.19888	0.18589	0.17074	0.15505	0.14422	0.14531	0.15775	0.17669	0.19563	0.21133
	43	0.2067	0.20352	0.19503	0.18229	0.16743	0.15204	0.14143	0.14249	0.1547	0.17327	0.19184	0.20723
	44	0.20065	0.19756	0.18932	0.17695	0.16253	0.14759	0.13729	0.13832	0.15017	0.1682	0.18623	0.20116
	45	0.19393	0.19095	0.18298	0.17103	0.15709	0.14265	0.13269	0.13369	0.14514	0.16257	0.17999	0.19443
	46	0.18528	0.18243	0.17481	0.1634	0.15008	0.13629	0.12677	0.12772	0.13866	0.15531	0.17196	0.18576
	47	0.17568	0.17297	0.16575	0.15493	0.1423	0.12922	0.1202	0.1211	0.13148	0.14726	0.16305	0.17613
	48	0.16847	0.16588	0.15896	0.14858	0.13647	0.12392	0.11527	0.11614	0.12609	0.14122	0.15636	0.16891