
sap2012

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SAP2012 energy calculation method in Python.

INTRODUCTION

SAP2012 is the Standard Assessment Procedure 2012, the UK Government's energy calculation method for the building regulation compliance for new dwellings.

SAP2012 is developed and published by the Building Research Establishment: <https://www.bregroup.com/sap/standard-assessment-procedure-sap-2012>

This Python package contains the calculation methods and data in the SAP2012 methodology. It allows the user to specify the inputs needed for a SAP calculation and then to run a SAP calculation based on these inputs.

1.1 Installation

Available on PyPi. Download using the command `pip install sap2012`.

If using the Anaconda distribution, this command is run using the Anaconda prompt.

1.2 Issues & feature requests?

Please raise them on the [GitHub Issues](#) page.

1.3 Contributions

All contributions welcome. Please send your [pull requests](#).

1.4 Contacts

<https://www.lboro.ac.uk/departments/abce/staff/steven-firth/>

APPROACH

The package is designed to represent the SAP calculation method as simply as possible, to allow for flexibility and customisation.

Each section of the SAP2012 calculation method is implemented as a separate Python function which takes the input data as a series of arguments and returns the calculation results. For example, the method for calculating ventilation rates (SAP worksheet Section 2) is given by the `ventilation_rates` function.

A complete SAP calculation is run using the `calculate_worksheet` function.

Note: This is a partial implementation of the Standard Assessment Procedure for the most common use case. The complete procedure includes many additional calculation options in Appendices and many additional reference tables.

Note: It is recommended that users carry out their own validation of the calculation results given by this Python package. The package has been validated for a common use case. But there are many edge cases possible given the complex nature of the SAP procedure and all possible edge cases have not been checked.

QUICK EXAMPLE

This example:

- Imports the *calculate_worksheet* function.
- Reads in the ‘inputs’ dictionary from a json file (available to view [here](#)).
- Runs the *calculate_worksheet* function with the ‘inputs’ dictionary.
- Prints the results of the *SAP_rating* section of the SAP worksheet (the full result dictionary is available to view [here](#)).

```
>>> from sap2012 import calculate_worksheet
>>> import json
>>> with open('inputs.json') as f:
>>>     inputs=json.load(f)
>>> result=calculate_worksheet(inputs)
>>> print(result['SAP_rating'])
{'energy_cost_factor': 1.7754795340546146, 'SAP_rating_value': 75.23206049993813}
```

The format required for the ‘inputs’ dictionary is given in the documentation of the *calculate_worksheet* function.

The return value of the *calculate_worksheet* function is a dictionary containing the model outputs. This is also described in the *calculate_worksheet* documentation.

CALCULATE_WORKSHEET FUNCTION

`sap2012.SAP_worksheet.calculate_worksheet.calculate_worksheet(inputs)`

This function runs the complete set of calculations for the SAP2012 worksheet.

Parameters

inputs (*dict*) – A dictionary of the SAP model inputs.

Returns

A dictionary with the results of all the calculation sections.

Return type

dict

SAP Calculation Sections

The SAP calculation sections are run as given in the order below:

- *overall_dwelling_dimensions* (Section 1)
- *ventilation_rates* (Section 2)
- *heat_losses_and_heat_loss_parameter* (Section 3)
- *water_heating_requirement* (Section 4)
- *internal_gains_appendix_L*
- *internal_gains* (Section 5)
- *solar_gains_appendix_U3*
- *solar_gains* (Section 6)
- *utilisation_factor_for_heating_table_9a*
- *temperature_reduction_when_heating_is_off_table_9b*
- *heating_requirement_table_9c*
- *mean_internal_temperature* (Section 7)
- *utilisation_factor_for_heating_whole_house_table_9a*
- *space_heating_requirement* (Section 8)
- *energy_requirements* (Section 9)
- *fuel_costs* (Section 10)
- *SAP_rating* (Section 11)
- *CO2_emissions* (Section 12)

Inputs

The 'inputs' dictionary holds all the inputs to run a complete SAP calculation. The dictionary is a collection of 18 individual dictionaries which contain the model inputs to individual calculation sections as listed above.

To see definitions of the model inputs, please see the documentation for the individual calculation sections.

For the *calculate_worksheet* function, not all inputs need to be provided for all calculation sections. This is because some inputs for later sections are calculated as outputs by earlier sections.

An example of a valid 'inputs' dictionary is:

```
{'overall_dwelling_dimensions':
  {'area':[0,63,63],
   'average_storey_height': [0,2.5,2.75]}
 'ventilation_rates':
  {'number_of_chimneys_main_heating': 0,
   'number_of_chimneys_secondary_heating': 0,
   'number_of_chimneys_other': 0,
   'number_of_open_flues_main_heating': 0,
   'number_of_open_flues_secondary_heating': 0,
   'number_of_open_flues_other': 0,
   'number_of_intermittant_fans_total': 0,
   'number_of_passive_vents_total': 0,
   'number_of_flueless_gas_fires_total': 0,
   'air_permeability_value_q50': 11.78,
   'number_of_storeys_in_the_dwelling': 2,
   'structural_infiltration': 0,
   'suspended_wooden_ground_floor_infiltration': 0,
   'no_draft_lobby_infiltration': 0,
   'percentage_of_windows_and_doors_draught_proofed': 0,
   'number_of_sides_on_which_dwelling_is_sheltered': 2,
   'monthly_average_wind_speed': [4.5, 4.5, 4.4, 3.9, 3.8, 3.4, 3.3, 3.3, 3.5, 3.
↪8, 3.9, 4.1],
   'applicable_case': 'natural ventilation or whole house positive input_
↪ventilation from loft',
   'mechanical_ventilation_air_change_rate_through_system': 0.5,
   'exhaust_air_heat_pump_using_Appendix_N': False,
   'mechanical_ventilation_throughput_factor': None,
   'efficiency_allowing_for_in_use_factor': None}
 'heat_losses_and_heat_loss_parameter':
  {'solid_door_net_area': 1.5,
   'solid_door_u_value': 3,
   'semi_glazed_door_net_area': 10.6,
   'semi_glazed_door_u_value': 1.4,
   'window_net_area': 23,
   'window_u_value': 2,
   'roof_window_net_area': 0,
   'roof_window_u_value': None,
   'basement_floor_net_area': 0,
   'basement_floor_u_value': None,
   'basement_floor_heat_capacity': None,
   'ground_floor_net_area': 63,
```

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```

    'ground_floor_u_value': 0.63,
    'ground_floor_heat_capacity': 20,
    'exposed_floor_net_area': 0,
    'exposed_floor_u_value': None,
    'exposed_floor_heat_capacity': None,
    'basement_wall_gross_area': 0,
    'basement_wall_opening': 0,
    'basement_wall_u_value': None,
    'basement_wall_heat_capacity': None,
    'external_wall_gross_area': 120,
    'external_wall_opening': 35.1,
    'external_wall_u_value': 1.5,
    'external_wall_heat_capacity': 190,
    'roof_gross_area': 63,
    'roof_opening': 0,
    'roof_u_value': 0.14,
    'roof_heat_capacity': 9,
    'party_wall_net_area': 47,
    'party_wall_u_value': 0.5,
    'party_wall_heat_capacity': 180,
    'party_floor_net_area': 0,
    'party_floor_heat_capacity': None,
    'party_ceiling_net_area': 39,
    'party_ceiling_heat_capacity': 100,
    'internal_wall_net_area': 131,
    'internal_wall_heat_capacity': 9,
    'internal_floor_net_area': 63,
    'internal_floor_heat_capacity': 18,
    'internal_ceiling_net_area': 63,
    'internal_ceiling_heat_capacity': 9,
    'thermal_bridges_appendix_k': 36.9
  },
  'water_heating_requirement':
    { 'assumed_occupancy': 2.88,
      'V_dm_table_1c': [1.1, 1.06, 1.02, 0.98, 0.94, 0.9, 0.9, 0.94, 0.98, 1.02, 1.
↪06, 1.1],
      'days_in_month': [31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31],
      'T_table_1d': [41.2, 41.4, 40.1, 37.6, 36.4, 33.9, 30.4, 33.4, 33.5, 36.3, 39.
↪4, 39.9],
      'water_storage_loss_manufacturer': 0,
      'temperature_factor_table_2b': 0,
      'storage_volume_litres': 0,
      'hot_water_storage_loss_table_2': 0,
      'volume_factor_table_2a': 0,
      'Vs_appendix_G3': 0,
      'solar_storage_WWHRs_factor': 0,
      'primary_circuit_loss_table_3': [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      'combi_loss_table_3': [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      'solar_DHW_input_appendix_G': [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
    },
  'internal_gains_appendix_L':
    { 'number_of_low_energy_light_bulbs': 0,

```

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```

    'total_number_of_light_bulbs': 10,
    'frame_factor': 0.7,
    'window_area': 23,
    'light_access_factor_table_6d': 0,
    'light_transmittance_factor_table_6d': 0,
    'month_number': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]
  },
  'internal_gains':
    {'pumps_and_fans_gains': [3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3]}
  },
  'solar_gains_appendix_U3':
    {'solar_radiation_horizontal_plane_monthly_table_U3': [28, 55, 97, 153, 191, ↵
↵208, 194, 208, 163, 69, 35, 23],
    'solar_declination_monthly_table_U3': [-20.7, -12.8, -1.8, 9.8, 18.8, 23.1, ↵
↵21.2, 13.7, 2.9, -8.7, -18.4, -23],
    'location_latitude_table_U4': 53.4,
    'p_tilt': 90
  },
  'solar_gains':
    {'access_factor_table_6d_north': 0.77,
    'access_factor_table_6d_north_east': 0,
    'access_factor_table_6d_east': 0.77,
    'access_factor_table_6d_south_east': 0,
    'access_factor_table_6d_south': 0.77,
    'access_factor_table_6d_south_west': 0,
    'access_factor_table_6d_west': 0,
    'access_factor_table_6d_north_west': 0,
    'access_factor_table_6d_roof_windows': 0,
    'area_north': 10,
    'area_north_east': 0,
    'area_east': 4.9,
    'area_south_east': 0,
    'area_south': 11.9,
    'area_south_west': 0,
    'area_west': 0,
    'area_north_west': 0,
    'area_roof_windows': 0,
    'solar_flux_roof_windows': [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    'g_table_6b_north': 0.72,
    'g_table_6b_north_east': 0,
    'g_table_6b_east': 0.72,
    'g_table_6b_south_east': 0,
    'g_table_6b_south': 0.72,
    'g_table_6b_south_west': 0,
    'g_table_6b_west': 0,
    'g_table_6b_north_west': 0,
    'g_table_6b_roof_windows': 0,
    'FF_table_6b_north': 0.72,
    'FF_table_6b_north_east': 0,
    'FF_table_6b_east': 0.72,
    'FF_table_6b_south_east': 0,
    'FF_table_6b_south': 0.72,
  }
}

```

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```

    'FF_table_6b_south_west': 0,
    'FF_table_6b_west': 0,
    'FF_table_6b_north_west': 0,
    'FF_table_6b_roof_windows': 0
  },
  'utilisation_factor_for_heating_table_9a':
    {
      'temperature_during_heating_living_room': 20,
      'heating_controls': 2,
      'monthly_external_temperature_table_U1': [4.3, 4.8, 6.6, 9, 11.8, 14.8, 16.6,
→ 16.5, 14, 10.5, 7.1, 4.2]
    },
  'temperature_reduction_when_heating_is_off_table_9b':
    {
      'hours_heating_is_off_1_weekday_living_room': 8,
      'hours_heating_is_off_2_weekday_living_room': 8,
      'hours_heating_is_off_1_weekend_living_room': 8,
      'hours_heating_is_off_2_weekend_living_room': 8,
      'hours_heating_is_off_1_weekday_rest_of_dwelling': 8,
      'hours_heating_is_off_2_weekday_rest_of_dwelling': 8,
      'hours_heating_is_off_1_weekend_rest_of_dwelling': 8,
      'hours_heating_is_off_2_weekend_rest_of_dwelling': 8,
      'responsiveness_of_heating_system': 1
    },
  'heating_requirement_table_9c':
    {
      'temperature_adjustment_table_4e': 0
    },
  'mean_internal_temperature':
    {
      'living_room_area': 16
    },
  'energy_requirements':
    {
      'fraction_of_space_heat_secondary_system': 0,
      'fraction_of_space_heat_from_main_system_2': 0,
      'efficiency_of_main_space_heating_system_1': 88.8,
      'efficiency_of_main_space_heating_system_2': 0,
      'efficiency_of_secondary_space_heating_system': 0,
      'cooling_system_energy_efficiency_ratio_table_10c': 0,
      'water_heater_type': 'gas/oil boiler main system',
      'efficiency_of_water_heater': 80,
      'efficiency_of_water_heater_adjustment_table_4c': 0,
      'space_cooling_requirement_monthly': [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      'electricity_demand_mechanical_ventilation_fans_table_4f': 0,
      'electricity_demand_warm_air_heating_systems_fans_table_4f': 0,
      'electricity_demand_central_heating_pump_or_water_pump_table_4f': 0,
      'electricity_demand_oil_boiler_pump_table_4f': 0,
      'electricity_demand_boiler_flue_fan_table_4f': 0,
      'electricity_demand_keep_hot_facility_gas_combi_boiler_table_4f': 0,
      'electricity_demand_pump_for_solar_water_heating_table_4f': 0,
      'electricity_demand_pump_for_storage_WWHRs_Table_G3': 0,
      'electricity_generated_by_PV_appendix_M': [0],
      'electricity_generated_by_wind_turbine_appendix_M': [0],
      'electricity_used_or_generated_by_micro_CHP_appendix_N': [0],
      'electricity_generated_by_hydro_electric_generator_appendix_M': [0],
      'appendix_Q_energy_saved': [0], 'appendix_Q_energy_used': [0]
    }

```

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```

    },
    'fuel_costs':
    {
        'space_heating_fuel_price_main_system_1': 3.48,
        'space_heating_fuel_price_main_system_2': 0,
        'space_heating_fuel_price_secondary': 0,
        'water_heating_high_rate_fraction_table_13': 0,
        'water_heating_low_rate_fraction_table_13': 1,
        'high_rate_fuel_price': 0,
        'low_rate_fuel_price': 3.48,
        'water_heating_fuel_price_other': 0,
        'space_cooling_fuel_used': 0,
        'space_cooling_fuel_price': 0,
        'electricity_for_pumps_fans_electric_keep_hot': 0,
        'fuel_price_for_pumps_fans_electric_keep_hot': 0,
        'fuel_price_for_lighting': 13.19,
        'additional_standing_charges_table_12': 0,
        'energy_saving_generation_technologies': [0],
        'energy_saving_generation_technologies_fuel_price': [0],
        'appendix_Q_energy_used_fuel_price': [0],
        'appendix_Q_energy_saved_fuel_price': [0]
    },
    'SAP_rating':
    {
        'energy_cost_deflator': 0.42
    },
    'CO2_emissions':
    {
        'space_heating_fuel_emission_factor_main_system_1': 0.216,
        'space_heating_fuel_emission_factor_main_system_2': 0,
        'space_heating_fuel_emission_factor_secondary': 0,
        'water_heating_fuel_emission_factor': 0.216,
        'space_cooling_fuel_emission_factor': 0,
        'fuel_emission_factor_for_pumps_fans_electric_keep_hot': 0,
        'fuel_emission_factor_for_lighting': 0.519,
        'energy_saving_generation_technologies_fuel_emission_factor': [0],
        'appendix_Q_energy_used_fuel_emission_factor': [0],
        'appendix_Q_energy_saved_fuel_emission_factor': [0]
    }
}

```

Outputs

The `calculate_worksheet` function returns a dictionary containing the outputs of all SAP calculation sections.

The output dictionary is a collection of dictionaries, where each dictionary holds the outputs of an individual calculation section.

An example of an output dictionary as returned by the `calculate_worksheet` function is:

```

{
    "overall_dwelling_dimensions": {
        "volume": [
            0,
            157.5,

```

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```

        173.25
    ],
    "total_floor_area": 126,
    "dwelling_volume": 330.75
},
"ventilation_rates": {
    "number_of_chimneys_total": 0,
    "number_of_chimneys_m3_per_hour": 0.0,
    "number_of_open_flues_total": 0,
    "number_of_open_flues_m3_per_hour": 0.0,
    "number_of_intermittant_fans_m3_per_hour": 0.0,
    "number_of_passive_vents_m3_per_hour": 0.0,
    "number_of_flueless_gas_fires_m3_per_hour": 0.0,
    "infiltration_due_to_chimneys_flues_fans_PSVs": 0.0,
    "additional_infiltration": null,
    "window_infiltration": null,
    "infiltration_rate": null,
    "infiltration_rate2": 0.589,
    "shelter_factor": 0.85,
    "infiltration_rate_incorporating_shelter_factor": 0.5006499999999999,
    "wind_factor": [
        1.125,
        1.125,
        1.1,
        0.975,
        0.95,
        0.85,
        0.825,
        0.825,
        0.875,
        0.95,
        0.975,
        1.025
    ],
    "adjusted_infiltration_rate_allowing_for_shelter_and_wind_speed": [
        0.56323125,
        0.56323125,
        0.550715,
        0.4881337499999999,
        0.4756174999999999,
        0.42555249999999994,
        0.41303624999999994,
        0.41303624999999994,
        0.43806874999999995,
        0.4756174999999999,
        0.4881337499999999,
        0.5131662499999999
    ],
    "exhaust_air_heat_pump_air_change_rate_through_system": null,
    "effective_air_change_rate": [
        0.6586147204882813,
        0.6586147204882813,

```

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```

        0.6516435056125,
        0.6191372789445312,
        0.6131060031531249,
        0.590547465128125,
        0.5852994719070312,
        0.5852994719070312,
        0.5959521148632813,
        0.6131060031531249,
        0.6191372789445312,
        0.6316698000695312
    ]
},
"heat_losses_and_heat_loss_parameter": {
    "solid_floor_UA": 4.5,
    "semi_glazed_door_UA": 14.839999999999998,
    "window_UA": 46,
    "roof_window_UA": 0,
    "basement_floor_UA": 0,
    "basement_floor_Ak": 0,
    "ground_floor_UA": 39.69,
    "ground_floor_Ak": 1260,
    "exposed_floor_UA": 0,
    "exposed_floor_Ak": 0,
    "basement_wall_net_area": 0,
    "basement_wall_UA": 0,
    "basement_wall_Ak": 0,
    "external_wall_net_area": 84.9,
    "external_wall_UA": 127.35000000000001,
    "external_wall_Ak": 16131.000000000002,
    "roof_net_area": 63,
    "roof_UA": 8.82,
    "roof_Ak": 567,
    "total_area_of_external_elements": 246.0,
    "party_wall_UA": 23.5,
    "party_wall_Ak": 8460,
    "party_floor_Ak": 0,
    "party_ceiling_Ak": 3900,
    "internal_wall_Ak": 1179,
    "internal_floor_Ak": 1134,
    "internal_ceiling_Ak": 567,
    "fabric_heat_loss": 264.7,
    "heat_capacity": 33198.0,
    "thermal_mass_parameter": 263.4761904761905,
    "thermal_bridges": 36.9,
    "total_fabric_heat_loss": 301.59999999999997,
    "ventilation_heat_loss_calculated_monthly": [
        71.88615020449468,
        71.88615020449468,
        71.12525952884035,
        67.57728615359822,
        66.9189874791557,
        64.45677945007202,

```

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```

        63.8839741099727,
        63.8839741099727,
        65.04668345703999,
        66.9189874791557,
        67.57728615359822,
        68.94517950308916
    ],
    "heat_transfer_coefficient": [
        373.48615020449466,
        373.48615020449466,
        372.7252595288403,
        369.1772861535982,
        368.51898747915567,
        366.056779450072,
        365.4839741099727,
        365.4839741099727,
        366.64668345703996,
        368.51898747915567,
        369.1772861535982,
        370.5451795030891
    ],
    "average_heat_transfer_coefficient": 369.1088914861237,
    "heat_loss_parameter": [
        2.9641757952737673,
        2.9641757952737673,
        2.9581369803876214,
        2.9299784615364937,
        2.924753868882188,
        2.905212535318032,
        2.9006664611902595,
        2.9006664611902595,
        2.909894313151111,
        2.924753868882188,
        2.9299784615364937,
        2.940834757961025
    ],
    "average_heat_loss_parameter": 0.27899387111573976
},
"water_heating_requirement": {
    "annual_hot_water_usage_litres_per_day": 108.0,
    "hot_water_usage_in_litres_per_day_monthly": [
        118.80000000000001,
        114.48,
        110.16,
        105.84,
        101.52,
        97.2,
        97.2,
        101.52,
        105.84,
        110.16,
        114.48,

```

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```

    118.800000000000001
  ],
  "energy_content_of_water_used": [
    176.176968000000002,
    154.0855008,
    159.002434799999997,
    138.622176,
    133.011278399999998,
    114.778619999999999,
    106.359263999999998,
    122.048810399999998,
    123.50646,
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},

```

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```

"heating_requirement_table_9c": {
  "T_weekday_living_room": [
    16.661783075752005,
    16.901493535998505,
    17.460312792664816,
    18.170349566383155,
    18.879995830448042,
    19.539908700422654,
    19.819731443698018,
    19.836221096303845,
    19.402016928436044,
    18.369487763300068,
    17.412944831516622,
    16.620708157914965
  ],
  "T_weekend_living_room": [
    16.661783075752005,
    16.901493535998505,
    17.460312792664816,
    18.170349566383155,
    18.879995830448042,
    19.539908700422654,
    19.819731443698018,
    19.836221096303845,
    19.402016928436044,
    18.369487763300068,
    17.412944831516622,
    16.620708157914965
  ],
  "mean_internal_temperature_living_room_T1_Table_9c": [
    16.661783075752005,
    16.901493535998505,
    17.460312792664816,
    18.170349566383155,
    18.879995830448042,
    19.539908700422654,
    19.81973144369802,
    19.83622109630384,
    19.402016928436044,
    18.369487763300068,
    17.412944831516622,
    16.620708157914965
  ],
  "T_weekday_rest_of_dwelling": [
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    15.248454331772159,
    15.802067132460678,
    16.500761119194593,
    17.163047614137596,
    17.677659847956974,
    17.79240196936638,
    17.7922764893629,

```

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```

        17.584632176731052,
        16.70520961386205,
        15.767887773508614,
        14.976849833091302
    ],
    "T_weekend_rest_of_dwelling": [
        15.011357898684903,
        15.248454331772159,
        15.802067132460678,
        16.500761119194593,
        17.163047614137596,
        17.677659847956974,
        17.79240196936638,
        17.7922764893629,
        17.584632176731052,
        16.70520961386205,
        15.767887773508614,
        14.976849833091302
    ],
    "mean_internal_temperature_rest_of_dwelling_T2_table_9c": [
        15.011357898684903,
        15.24845433177216,
        15.802067132460678,
        16.500761119194593,
        17.163047614137596,
        17.677659847956974,
        17.79240196936638,
        17.7922764893629,
        17.584632176731052,
        16.70520961386205,
        15.767887773508614,
        14.976849833091302
    ]
},
"mean_internal_temperature": {
    "living_area_fraction": 0.12698412698412698,
    "mean_internal_temp_whole_dwelling": [
        15.220935698947391,
        15.45836407199138,
        16.01263800994692,
        16.712772350583617,
        17.381072784462734,
        17.91413589271452,
        18.049840632773574,
        18.05182501087921,
        17.815411192820577,
        16.916546521727195,
        15.976783907858838,
        15.185593747354623
    ]
},
"utilisation_factor_for_heating_whole_house_table_9a": {

```

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```
"time_constant_whole_house": [  
    24.690786155303304,  
    24.690786155303304,  
    24.741190544273064,  
    24.97896542538086,  
    25.02358624652486,  
    25.19190241612353,  
    25.23138446527864,  
    25.23138446527864,  
    25.151370741219782,  
    25.02358624652486,  
    24.97896542538086,  
    24.886753833994458  
],  
"a_whole_house": [  
    2.646052410353554,  
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    2.6494127029515377,  
    2.6652643616920573,  
    2.6682390831016574,  
    2.679460161074902,  
    2.6820922976852426,  
    2.6820922976852426,  
    2.6767580494146523,  
    2.6682390831016574,  
    2.6652643616920573,  
    2.659116922266297  
],  
"heat_loss_rate_whole_house": [  
    4078.8182308306937,  
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    3508.3279451084923,  
    2847.380365108968,  
    2056.731291577679,  
    1139.9505556569516,  
    529.8935162922027,  
    567.1671720993851,  
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    2364.619227299804,  
    3277.1069928752577,  
    4070.6588070615326  
],  
"y_whole_house": [  
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    0.7693731707585074,  
    1.3891702258114667,  
    2.850407791714455,  
    2.966468147773947,  
    1.1749895716717405,
```

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        0.5250504537977673,
        0.33897434319961434,
        0.261434398953099
    ],
    "utilisation_factor_for_heating_whole_house": [
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        0.9656434303833015,
        0.9441263026325147,
        0.9002533073727103,
        0.8145321748485704,
        0.600728558381495,
        0.3368108736174081,
        0.3247811027290035,
        0.6670380534773137,
        0.9060274656261859,
        0.9623032505637008,
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    ]
},
"space_heating_requirement": {
    "useful_gains": [
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        1336.1644527521073,
        1386.6165431836682,
        1288.9107246331912,
        951.3049568842453,
        508.7233898946552,
        546.4387978972308,
        1096.4118806846304,
        1124.8733247018736,
        1068.9795607282836,
        1041.8573883663541
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    "heat_loss_rate_for_mean_internal_temperature": [
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        3508.3279451084923,
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        529.8935162922027,
        567.1671720993851,
        1398.9078598725332,
        2364.619227299804,
        3277.1069928752577,
        4070.6588070615326
    ],
    "space_heating_requirement_monthly": [
        2222.0637912700713,
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        1051.749951786216,
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        922.3709515328603,
        1589.8517511458213,
        2253.428255509213
    ],
    "space_heating_requirement_yearly": 12454.903631585687,
    "space_heating_requirement_yearly_per_m2": 98.84844152052132
},
"energy_requirements": {
    "fraction_of_space_heat_from_main_systems": 1,
    "fraction_of_total_space_heat_from_main_system_1": 1,
    "fraction_of_total_space_heat_from_main_system_2": 0,
    "space_heating_fuel_main_system_1": [
        2502.3240892680983,
        2075.7842000493665,
        1819.9207638661605,
        1184.403098858351,
        643.3091236561924,
        0,
        0,
        0,
        0,
        1038.7060265009688,
        1790.3735936326816,
        2537.644431879745
    ],
    "space_heating_fuel_main_system_2": [
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        0.0
    ],
    "space_heating_fuel_secondary_system": [
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        0.0,
        0.0,
        0.0,
        0.0,
        0.0,
        0.0
    ]
}

```

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0.0,
0.0,
0.0,
0.0,
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0.0
],
"efficiency_of_water_heater_table_4a": [
88.08818571043759,
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87.67687598232241,
86.99272176591167,
84.54075372718351,
81.03583975422129,
80.89937924581712,
85.40059859744034,
87.50076184715809,
87.93010620821106,
88.1177553227744
],
"fuel_for_water_heating_monthly": [
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158.10574275929866,
152.8993181267732,
135.76720686734745,
131.2496598080352,
150.8649529054458,
144.62013384962597,
164.49556479453074,
178.6830185647248,
193.62497940327455
],
"space_cooling_fuel_monthly": [
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0,
0,
0,
0,
0,
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0,
0,
0
],
"space_heating_fuel_used_main_system_1": 13592.465327711565,
"space_heating_fuel_used_main_system_2": 0.0,
"space_heating_fuel_used_secondary": 0.0,

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```

    "water_fuel_used": 1966.1244892592,
    "space_cooling_fuel_used": 0,
    "electricity_for_pumps_fans_electric_keep_hot": 0,
    "energy_saving_generation_technologies_total": 0,
    "appendix_Q_energy_total": 0,
    "energy_for_lighting": 1375.548784405473,
    "total_energy_used": 16934.13860137624
  },
  "fuel_costs": {
    "space_heating_main_system_1_fuel_cost": 473.01779340436246,
    "space_heating_main_system_2_fuel_cost": 0.0,
    "space_heating_secondary_fuel_cost": 0.0,
    "water_heating_high_rate_fuel_cost": 0.0,
    "water_heating_low_rate_fuel_cost": 68.42113222622015,
    "water_heating_cost_other": 0.0,
    "space_cooling_cost": 0.0,
    "pumps_fan_keep_hot_cost": 0.0,
    "lighting_cost": 181.4348846630819,
    "appendix_Q_fuel_cost": 0.0,
    "energy_saving_total_fuel_cost": 0.0,
    "additional_standing_charges_table_12": 0,
    "total_fuel_cost": 722.8738102936645
  },
  "SAP_rating": {
    "energy_cost_factor": 1.7754795340546146,
    "SAP_rating_value": 75.23206049993813
  },
  "CO2_emissions": {
    "space_heating_main_system_1_emissions": 2935.972510785698,
    "space_heating_main_system_2_emissions": 0.0,
    "space_heating_secondary_emissions": 0.0,
    "water_used_emissions": 424.68288967998717,
    "space_cooling_used_emissions": 0,
    "pumps_fans_electric_keep_hot_emissions": 0,
    "lighting_emissions": 713.9098191064405,
    "appendix_Q_used_emissions": [
      0
    ],
    "appendix_Q_saved_emissions": [
      0
    ],
    "energy_saving_generation_technologies_emissions": [
      0
    ],
    "space_and_water_heating_emissions": 3360.655400465685,
    "appendix_Q_total_used_emissions": 0,
    "appendix_Q_total_saved_emissions": 0,
    "energy_saving_generation_technologies_total_emissions": 0,
    "total_CO2_emissions_yearly": 4074.5652195721254,
    "dwelling_CO2_emission_rate": 32.337819202953376,
    "CF": 23.82786678112354,
    "EI_rating": 68.07065851329446
  }

```

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```
}  
}
```

1. OVERALL DWELLING DIMENSIONS

`sap2012.SAP_worksheet.overall_dwelling_dimensions.overall_dwelling_dimensions`(*area, average_storey_height*)

Calculates the overall dwelling dimensions, Section 1.

Parameters

- **area** (*list (float)*) – A list of the areas of each floor. The first item is the basement, the second the ground floor etc. See (1a) to (1n).
- **average_storey_height** (*list (float)*) – A list of the average storey height of each floor. The first item is the basement, the second the ground floor etc. See (2a) to (2n).

Returns

A dictionary with keys (volume,total_floor_area,dwelling_volume).

- **volume** (*list (float)*) - A list of the volumes of each floor. The first item is the basement, the second the ground floor etc. See (3a) to (3n).
- **total_floor_area** (*float*) - See (4).
- **dwelling_volume** (*float*) - See (5).

Return type

dict

2. VENTILATION RATES

`sap2012.SAP_worksheet.ventilation_rates.ventilation_rates`(*number_of_chimneys_main_heating*,
number_of_chimneys_secondary_heating,
number_of_chimneys_other,
number_of_open_flues_main_heating,
number_of_open_flues_secondary_heating,
number_of_open_flues_other,
number_of_intermittant_fans_total,
number_of_passive_vents_total,
number_of_flueless_gas_fires_total,
dwelling_volume,
air_permeability_value_q50,
number_of_storeys_in_the_dwelling,
structural_infiltration, *suspended_wooden_ground_floor_infiltration*,
no_draft_lobby_infiltration, *percentage_of_windows_and_doors_draught_proofed*,
number_of_sides_on_which_dwelling_is_sheltered,
monthly_average_wind_speed,
applicable_case, *mechanical_ventilation_air_change_rate_through_system*,
exhaust_air_heat_pump_using_Appendix_N,
mechanical_ventilation_throughput_factor,
efficiency_allowing_for_in_use_factor)

Calculates the ventilation rates, Section 2.

Parameters

- `number_of_chimneys_main_heating` (*int*) –
- `number_of_chimneys_secondary_heating` (*int*) –
- `number_of_chimneys_other` (*int*) –
- `number_of_open_flues_main_heating` (*int*) –
- `number_of_open_flues_secondary_heating` (*int*) –
- `number_of_open_flues_other` (*int*) –
- `number_of_intermittant_fans_total` (*int*) –

- **number_of_passive_vents_total** (*int*) –
- **number_of_flueless_gas_fires_total** (*int*) –
- **dwelling_volume** (*float*) – See (5).
- **air_permeability_value_q50** (*float* or *None*) – See (17). Use *None* if not carried out.
- **number_of_storeys_in_the_dwelling** (*int*) – See (9).
- **structural_infiltration** (*float*) – See (11).
- **suspended_wooden_ground_floor_infiltration** (*float*) – See (12).
- **no_draft_lobby_infiltration** (*float*) – See (13).
- **percentage_of_windows_and_doors_draught_proofed** (*float*) – See (14).
- **number_of_sides_on_which_dwelling_is_sheltered** (*int*) – See (19).
- **monthly_average_wind_speed** (*list* (*float*)) – A list of the monthly wind speeds. 12 items, from Jan to Dec, see (22).
- **applicable_case** (*str*) – One of the following options: ‘balanced mechanical ventilation with heat recovery’; ‘balanced mechanical ventilation without heat recovery’; ‘whole house extract ventilation or positive input ventilation from outside’; or ‘natural ventilation or whole house positive input ventilation from loft’.
- **mechanical_ventilation_air_change_rate_through_system** (*float*) – See (23a).
- **exhaust_air_heat_pump_using_Appendix_N** (*bool*) – True if exhaust air heat pump using Appendix N, otherwise False.
- **mechanical_ventilation_throughput_factor** (*float*) – F_{mv} , see Equation N4.
- **efficiency_allowing_for_in_use_factor** (*float*) – In %, see (23c).

Returns

A dictionary with keys of (**number_of_chimneys_total**, **number_of_chimneys_m3_per_hour**, **number_of_open_flues_total**, **number_of_open_flues_m3_per_hour**, **number_of_intermittant_fans_m3_per_hour**, **number_of_passive_vents_m3_per_hour**, **number_of_flueless_gas_fires_m3_per_hour**, **infiltration_due_to_chimneys_flues_fans_PSVs**, **additional_infiltration**, **window_infiltration**, **infiltration_rate**, **infiltration_rate2**, **shelter_factor**, **infiltration_rate_incorporating_shelter_factor**, **wind_factor**, **adjusted_infiltration_rate_allowing_for_shelter_and_wind_speed**, **exhaust_air_heat_pump_air_change_rate_through_system**, **effective_air_change_rate**)

- **number_of_chimneys_total** (*int*) -
- **number_of_chimneys_m3_per_hour** (*float*) - See (6a).
- **number_of_open_flues_total** (*int*) -
- **number_of_open_flues_m3_per_hour** (*float*) - See (6b).
- **infiltration_due_to_chimneys_flues_fans_PSVs** (*float*) - See (8).
- **additional_infiltration** (*float*) - See (10).
- **window_infiltration** (*float*) - See (15).
- **infiltration_rate** (*float*) - See (16).
- **infiltration_rate2** (*float*) - See (18).

- **shelter_factor** ([float](#)) - See (20).
- **infiltration_rate_incorporating_shelter_factor** ([float](#)) - See (21).
- **wind_factor** list ([float](#)) - See (22a).
- **adjusted_infiltration_rate_allowing_for_shelter_and_wind_speed**: list ([float](#)) - See (22b).
- **exhaust_air_heat_pump_air_change_rate_through_system** ([float](#)) - See (23b).
- **effective_air_change_rate** list ([float](#)) - See (25).

Return type[dict](#)

3. HEAT LOSSES AND HEAT LOSS PARAMETER

```
sap2012.SAP_worksheet.heat_losses_and_heat_loss_parameter.heat_losses_and_heat_loss_parameter(solid_door_
solid_door_
semi_glazed
semi_glazed
win-
dow_net_area
win-
dow_u_value
roof_window
roof_window
base-
ment_floor_
base-
ment_floor_
base-
ment_floor_
ground_floor
ground_floor
ground_floor
ex-
posed_floor_
ex-
posed_floor_
ex-
posed_floor_
base-
ment_wall_
base-
ment_wall_
base-
ment_wall_
base-
ment_wall_
ex-
ter-
nal_wall_gross
ex-
ter-
nal_wall_opening
ex-
ter-
nal_wall_u_value
ex-
ter-
nal_wall_heat_loss
roof_gross_area
roof_opening
roof_u_value
roof_heat_loss
party_wall_
party_wall_
party_wall_
party_floor_
party_floor_
party_ceiling
party_ceiling
in-
ter-
nal_wall_net
in-
```

Calculates the heat losses and the heat loss parameter, Section 3.

Parameters

- **solid_door_net_area** (*float*) – See (26), in m².
- **solid_door_u_value** (*float* or *None*) – See (26), in W/m²K.
- **semi_glazed_door_net_area** (*float*) – See (26a), in m².
- **semi_glazed_door_u_value** (*float* or *None*) – See (26a), in W/m²K.
- **window_net_area** (*float*) – See (27), in m².
- **window_u_value** (*float* or *None*) – See (27), in W/m²K. For windows and roof windows, use effective window U-value. Calculated using formula $1/[(1/U\text{-value})+0.04]$ as given in paragraph 3.2.
- **roof_window_net_area** (*float*) – See (27a), in m². For windows and roof windows, use effective window U-value. Calculated using formula $1/[(1/U\text{-value})+0.04]$ as given in paragraph 3.2.
- **roof_window_u_value** (*float* or *None*) – See (27a), in W/m²K.
- **basement_floor_net_area** (*float*) – See (28), in m².
- **basement_floor_u_value** (*float* or *None*) – See (28), in W/m²K.
- **basement_floor_heat_capacity** (*float* or *None*) – See (28), in kJ/m²K.
- **ground_floor_net_area** (*float*) – See (28a), in m².
- **ground_floor_u_value** (*float* or *None*) – See (28a), in W/m²K.
- **ground_floor_heat_capacity** (*float* or *None*) – See (28a), in kJ/m²K.
- **exposed_floor_net_area** (*float*) – See (28b), in m².
- **exposed_floor_u_value** (*float* or *None*) – See (28b), in W/m²K.
- **exposed_floor_heat_capacity** (*float* or *None*) – See (28b), in kJ/m²K.
- **basement_wall_gross_area** (*float*) – See (29), in m².
- **basement_wall_opening** (*float*) – See (29), in m².
- **basement_wall_u_value** (*float* or *None*) – See (29), in W/m²K.
- **basement_wall_heat_capacity** (*float* or *None*) – See (29), in kJ/m²K.
- **external_wall_gross_area** (*float*) – See (29a), in m².
- **external_wall_opening** (*float*) – See (29a), in m².
- **external_wall_u_value** (*float* or *None*) – See (29a), in W/m²K.
- **external_wall_heat_capacity** (*float* or *None*) – See (29a), in kJ/m²K.
- **roof_gross_area** (*float*) – See (30), in m².
- **roof_opening** (*float*) – See (30), in m².
- **roof_u_value** (*float* or *None*) – See (30), in W/m²K.
- **roof_heat_capacity** (*float* or *None*) – See (30), in kJ/m²K.
- **party_wall_net_area** (*float*) – See (32), in m².
- **party_wall_u_value** (*float* or *None*) – See (32), in W/m²K.

- **party_wall_heat_capacity** (*float* or *None*) – See (32), in kJ/m2K.
- **party_floor_net_area** (*float*) – See (32a), in m2.
- **party_floor_heat_capacity** (*float* or *None*) – See (32a), in kJ/m2K.
- **party_ceiling_net_area** (*float*) – See (32b), in m2.
- **party_ceiling_heat_capacity** (*float* or *None*) – See (32b), in kJ/m2K.
- **internal_wall_net_area** (*float*) – See (32c), in m2.
- **internal_wall_heat_capacity** (*float* or *None*) – See (32c), in kJ/m2K.
- **internal_floor_net_area** (*float*) – See (32d), in m2.
- **internal_floor_heat_capacity** (*float* or *None*) – See (32d), in kJ/m2K.
- **internal_ceiling_net_area** (*float*) – See (32e), in m2.
- **internal_ceiling_heat_capacity** (*float* or *None*) – See (32e), in kJ/m2K.
- **total_floor_area** (*float*) – See (4).
- **thermal_bridges_appendix_k** (*float* or *None*) – in W/K. The transmission heat loss coefficient due to non-repeating thermal bridges as calculated using Appendix K. If *None*, then a simplified calculation is done in this module.
- **effective_air_change_rate** (*list* (of *floats*)) – See (25).
- **dwelling_volume** (*float*) – See (5), in m3.

Returns

A dictionary with keys of (*solid_floor_UA*, *semi_glazed_door_UA*, *window_UA*, *roof_window_UA*, *basement_floor_UA*, *basement_floor_Ak*, *ground_floor_UA*, *ground_floor_Ak*, *exposed_floor_UA*, *exposed_floor_Ak*, *basement_wall_net_area*, *basement_wall_UA*, *basement_wall_Ak*, *external_wall_net_area*, *external_wall_UA*, *external_wall_Ak*, *roof_net_area*, *roof_UA*, *roof_Ak*, *total_area_of_external_elements*, *party_wall_UA*, *party_wall_Ak*, *party_floor_Ak*, *party_ceiling_Ak*, *internal_wall_Ak*, *internal_floor_Ak*, *internal_ceiling_Ak*, *fabric_heat_loss*, *heat_capacity*, *thermal_mass_parameter*, *thermal_bridges*, *total_fabric_heat_loss*, *ventilation_heat_loss_calculated_monthly*, *heat_transfer_coefficient*, *average_heat_transfer_coefficient*, *heat_loss_parameter*, *average_heat_loss_parameter*)

- **solid_floor_UA** (*float*): See (26), in W/K.
- **semi_glazed_door_UA** (*float*): See (26a), in W/K.
- **window_UA** (*float*): See (27), in W/K.
- **roof_window_UA** (*float*): See (27a), in W/K.
- **basement_floor_UA** (*float*): See (28), in W/K.
- **basement_floor_Ak** (*float*): See (28), in kJ/K.
- **ground_floor_UA** (*float*): See (28a), in W/K.
- **ground_floor_Ak** (*float*): See (28a), in kJ/K.
- **exposed_floor_UA** (*float*): See (28b), in W/K.
- **exposed_floor_Ak** (*float*): See (28b), in kJ/K.
- **basement_wall_net_area** (*float*): See (29), in m2.
- **basement_wall_UA** (*float*): See (29), in W/K.

- **basement_wall_Ak** ([float](#)): See (29), in kJ/K.
- **external_wall_net_area** ([float](#)): See (29a), in m2.
- **external_wall_UA** ([float](#)): See (29a), in W/K.
- **external_wall_Ak** ([float](#)): See (29a), in kJ/K.
- **roof_net_area** ([float](#)): See (30), in m2.
- **roof_UA** ([float](#)): See (30), in W/K.
- **roof_Ak** ([float](#)): See (30), in kJ/K.
- **total_area_of_external_elements** ([float](#)): See (31), in m2.
- **party_wall_UA** ([float](#)): See (32), in W/K.
- **party_wall_Ak** ([float](#)): See (32), in kJ/K.
- **party_floor_Ak** ([float](#)): See (32a), in kJ/K.
- **party_ceiling_Ak** ([float](#)): See (32b), in kJ/K.
- **internal_wall_Ak** ([float](#)): See (32c), in kJ/K.
- **internal_floor_Ak** ([float](#)): See (32d), in kJ/K.
- **internal_ceiling_Ak** ([float](#)): See (32e), in kJ/K.
- **fabric_heat_loss** ([float](#)): See (33), in W/K.
- **heat_capacity** ([float](#)): See (34), in kJ/K.
- **thermal_mass_parameter** ([float](#)): See (35), in kJ/m2K.
- **thermal_bridges** ([float](#)): See (36), in W/K.
- **total_fabric_heat_loss** ([float](#)): See (37), in W/K.
- **ventilation_heat_loss_calculated_monthly** ([list](#) ([float](#))): See (82), in W/K.
- **heat_transfer_coefficient** ([list](#) ([float](#))): See (39), in W/K.
- **average_heat_transfer_coefficient** ([float](#)): See (39), in W/K.
- **heat_loss_parameter** ([list](#) ([float](#))): See (40), in W/m2K.
- **average_heat_loss_parameter** ([float](#)): See (40), in W/m2K.

Return type

[dict](#)

4. WATER HEATING REQUIREMENT

sap2012.SAP_worksheet.water_heating_requirement.**water_heating_requirement**(*assumed_occupancy*,
V_dm_table_1c,
days_in_month,
T_table_1d, *water_storage_loss_manufacturer*,
temperature_factor_table_2b,
storage_volume_litres,
hot_water_storage_loss_table_2,
volume_factor_table_2a,
Vs_appendix_G3,
so-lar_storage_WWHRs_factor,
primary_circuit_loss_table_3,
combi_loss_table_3,
so-lar_DHW_input_appendix_G)

Calculates water heating requirement, Section 4.

Parameters

- **assumed_occupancy** (*float*) – See (42). Calculated using equation from (42). If TFA > 13.9, $N = 1 + 1.76 * [1 - \exp(-0.000349 * (TFA - 13.9)^2)] + 0.0013 * (TFA - 13.9)$. if TFA ≤ 13.9, N = 1. Where TFA is the Total Floor Area.
- **V_dm_table_1c** (*list (float)*) – See Table 1c.
- **days_in_month** (*list (int)*) – List of the number of days in each month of the calendar year.
- **T_table_1d** (*list (float)*) – See Table 1d.
- **storage_volume_litres** (*int*) – See (47). Value is 0 if no tank in dwelling. If no tank or combi boiler enter '0'. If community heating enter '110'.
- **water_storage_loss_manufacturer** (*float or None*) – See (48). Value is None if unknown or no tank in dwelling.
- **temperature_factor_table_2b** (*float*) – See (49/53). Value is 0 if no tank in dwelling.
- **hot_water_storage_loss_table_2** (*float*) – See (51). Value is 0 if no tank in dwelling.
- **volume_factor_table_2a** (*float*) – See (52). Value is 0 if no tank in dwelling.

- **Vs_appendix_G3** (*float* or *None*) – See appendix G3. Only applies where solar storage is within dwelling.
- **solar_storage_WWHRs_factor** (*int* or *None*) – Applies to dwellings with solar storage.
- **primary_circuit_loss_table_3** (*float*) – See (59). Values found in Table 3.
- **combi_loss_table_3** (*float*) – See (61). Values found in Table 3.
- **solar_DHW_input_appendix_G** (*float* or *None*) – See Appendix G.

Returns

A dictionary with keys of (`annual_hot_water_usage_litres_per_day`, `hot_water_usage_in_litres_per_day_monthly`, `energy_content_of_water_used`, `distribution_loss`, `energy_lost_from_water_storage`, `water_storage_loss_monthly`, `total_heat_required_for_water_heating`, `output_from_water_heater_monthly`, `heat_gains_from_water_heating_monthly`)

- **annual_hot_water_usage_litres_per_day** (*float*): (43) in L.
- **hot_water_usage_in_litres_per_day_monthly** (*list* (*float*)): (44) in L.
- **energy_content_of_water_used** (*list* (*float*)): (45) in kWh/month.
- **distribution_loss** (*list* (*float*)): (46) in kWh/month.
- **energy_lost_from_water_storage** (*list* (*float*)): (50/55) in kWh/month.
- **water_storage_loss_monthly** (*list* (*float*)): (56) in kWh/month.
- **total_heat_required_for_water_heating** (*list* (*float*)): (62) in kWh/month.
- **output_from_water_heater_monthly** (*list* (*float*)): (64) in kWh/month.
- **heat_gains_from_water_heating_monthly** (*list* (*float*)): (65) in kWh/month.

Return type

dict

5. INTERNAL GAINS

```
sap2012.SAP_worksheet.internal_gains.internal_gains(metabolic_gains, lighting_gains,  
appliances_gains, cooking_gains,  
pumps_and_fans_gains, losses,  
water_heating_gains)
```

Calculates Internal Gains, Section 5.

Parameters

- **metabolic_gains** (*list (float)*) – Calculated using table 5. See (66), in W.
- **lighting_gains** (*list (float)*) – Calculated using table 5. See (67), in W.
- **appliances_gains** (*list (float)*) – Calculated using Table 5. See (68), in W.
- **cooking_gains** (*list (float)*) – Calculated using Table 5. See (69), in W.
- **pumps_and_fans_gains** (*list (float)*) – Calculated using Table 5a. See (70), in W.
- **losses** (*list (float)*) – Calculated using Table 5. See (71), in W.
- **water_heating_gains** (*list (float)*) – Calculated using Table 5. See (72), in W.

Returns

A dictionary with keys (`total_internal_gains`)

- **total_internal_gains** (*list (float)*): Sum of all internal gains. See (73), in W.

Return type

`dict`

6. SOLAR GAINS

```
sap2012.SAP_worksheet.solar_gains.solar_gains(access_factor_table_6d_north,
                                              access_factor_table_6d_north_east,
                                              access_factor_table_6d_east,
                                              access_factor_table_6d_south_east,
                                              access_factor_table_6d_south,
                                              access_factor_table_6d_south_west,
                                              access_factor_table_6d_west,
                                              access_factor_table_6d_north_west,
                                              access_factor_table_6d_roof_windows, area_north,
                                              area_north_east, area_east, area_south_east,
                                              area_south, area_south_west, area_west,
                                              area_north_west, area_roof_windows, solar_flux_north,
                                              solar_flux_north_east, solar_flux_east,
                                              solar_flux_south_east, solar_flux_south,
                                              solar_flux_south_west, solar_flux_west,
                                              solar_flux_north_west, solar_flux_roof_windows,
                                              g_table_6b_north, g_table_6b_north_east,
                                              g_table_6b_east, g_table_6b_south_east,
                                              g_table_6b_south, g_table_6b_south_west,
                                              g_table_6b_west, g_table_6b_north_west,
                                              g_table_6b_roof_windows, FF_table_6b_north,
                                              FF_table_6b_north_east, FF_table_6b_east,
                                              FF_table_6b_south_east, FF_table_6b_south,
                                              FF_table_6b_south_west, FF_table_6b_west,
                                              FF_table_6b_north_west, FF_table_6b_roof_windows,
                                              total_internal_gains)
```

Calculates Solar Gains, Section 6.

Also includes U3 from appendix U to calculate solar gains. This calculation is found in tables/solar_gains_appendix_U.

Parameters

- **access_factor_table_6d_north** (*float*) – See (74).
- **access_factor_table_6d_north_east** (*float*) –
- **access_factor_table_6d_east** (*float*) –
- **access_factor_table_6d_south_east** (*float*) –
- **access_factor_table_6d_south** (*float*) –
- **access_factor_table_6d_south_west** (*float*) –

- `access_factor_table_6d_west` (*float*) –
- `access_factor_table_6d_north_west` (*float*) –
- `access_factor_table_6d_roof_windows` (*float*) –
- `area_north` (*float*) – See (74) in m.
- `area_north_east` (*float*) – See (75) in m.
- `area_east` (*float*) – See (76) in m.
- `area_south_east` (*float*) – See (77) in m.
- `area_south` (*float*) – See (78) in m.
- `area_south_west` (*float*) – See (79) in m.
- `area_west` (*float*) – See (80) in m.
- `area_north_west` (*float*) – See (81) in m.
- `area_roof_windows` (*float*) – See (82) in m.
- `solar_flux_north` (*float*) –
- `solar_flux_north_east` (*float*) –
- `solar_flux_east` (*float*) –
- `solar_flux_south_east` (*float*) –
- `solar_flux_south` (*float*) –
- `solar_flux_south_west` (*float*) –
- `solar_flux_west` (*float*) –
- `solar_flux_north_west` (*float*) –
- `solar_flux_roof_windows` (*float*) –
- `g_table_6b_north` (*float*) – See (74).
- `g_table_6b_north_east` (*float*) – See (75).
- `g_table_6b_east` (*float*) – See (76).
- `g_table_6b_south_east` (*float*) – See (77).
- `g_table_6b_south` (*float*) – See (78).
- `g_table_6b_south_west` (*float*) – See (79).
- `g_table_6b_west` (*float*) – See (80).
- `g_table_6b_north_west` (*float*) – See (81).
- `g_table_6b_roof_windows` (*float*) – See (82).
- `FF_table_6b_north` (*float*) – See (74).
- `FF_table_6b_north_east` (*float*) – See (75).
- `FF_table_6b_east` (*float*) – See (76).
- `FF_table_6b_south_east` (*float*) – See (77).
- `FF_table_6b_south` (*float*) – See (78).
- `FF_table_6b_south_west` (*float*) – See (79).

- **FF_table_6b_west** (*float*) – See (80).
- **FF_table_6b_north_west** (*float*) – See (81).
- **FF_table_6b_roof_windows** (*float*) – See (82).

Returns

A dictionary with keys of (gains_north, gains_north_east, gains_east, gains_south_east, gains_south, gains_south_west, gains_west, gains_north_west, gains_roof_windows, solar_gains_watts, total_internal_and_solar_gains)

- **gains_north** (*list (float)*): See (74).
- **gains_north_east** (*list (float)*): See (75).
- **gains_east** (*list (float)*): See (76).
- **gains_south_east** (*list (float)*): See (77).
- **gains_south** (*list (float)*): See (78).
- **gains_south_west** (*list (float)*): See (79).
- **gains_west** (*list (float)*): See (80).
- **gains_north_west** (*list (float)*): See (81).
- **gains_roof_windows** (*list (float)*): See (82).
- **solar_gains_watts** (*list (float)*): See (83) in W.
- **total_internal_and_solar_gains** (*list (float)*): See (84) in W.

Return type

dict

7. MEAN INTERNAL TEMPERATURE

`sap2012.SAP_worksheet.mean_internal_temperature.mean_internal_temperature`(*mean_internal_temperature_living_ro*
mean_internal_temperature_rest_of_d
living_room_area,
total_floor_area,
tempera-
ture_adjustment_table_4e)

Calculates Mean Internal Temperature, Section 7.

Parameters

- **mean_internal_temperature_living_room_T1_Table_9c** (*list (float)*) – See (87) in degC.
- **mean_internal_temperature_rest_of_dwelling_T2_table_9c** (*list (float)*) – See (90) in degC.
- **living_room_area** (*float*) – See (91) in m.
- **total_floor_area** (*float*) – in m.
- **temperature_adjustment_table_4e** (*float*) – See (93) in degC. Adjustments found in table 4a.

Returns

A dictionary with keys of (*living_area_fraction*, *mean_internal_temp_whole_dwelling*)

- **living_area_fraction** (float):
- **mean_internal_temp_whole_dwelling** (float): See (92) in degC.

Return type

dict

8. SPACE HEATING REQUIREMENT

`sap2012.SAP_worksheet.space_heating_requirement.space_heating_requirement` (*utilisation_factor_for_heating_whole_to-
tal_internal_and_solar_gains,
monthly_external_temperature_table_
mean_internal_temp_whole_dwelling,
heat_transfer_coefficient,
days_in_month,
total_floor_area*)

Calculates Space Heating Requirement, Section 8.

Parameters

- `utilisation_factor_for_gains_table_9a` (*float*) – See (94).
- `total_gains_internal_and_solar` (*float*) – See (84) in W.
- `monthly_external_temperature_table_U1` (*float*) – See (96) in degC.
- `mean_internal_temperature_whole_dwelling` (*float*) – See (92) in degC.
- `heat_transfer_coefficient` (*float*) – See (39).
- `days_in_month` (*float*) –
- `total_floor_area` (*float*) – in m.

Returns

A dictionary with keys of (`useful_gains`, `heat_loss_rate_for_mean_internal_temperature`,
`space_heating_requirement_monthly`, `space_heating_requirement_yearly`,
`space_heating_requirement_yearly_per_m2`)

- `useful_gains` (*float*): See (95) in W.
- `heat_loss_rate_for_mean_internal_temperature` (*float*): See (97) in W.
- `space_heating_requirement_monthly` (*float*): See (98) in kWh/month.
- `space_heating_requirement_yearly` (*float*): See (98) in kWh.
- `space_heating_requirement_yearly_per_m2` (*float*): See (99) in kWh/m2/yr.

Return type

dict

9. ENERGY REQUIREMENTS

sap2012.SAP_worksheet.energy_requirements.**energy_requirements**(*fraction_of_space_heat_secondary_system*,
fraction_of_space_heat_from_main_system_2,
efficiency_of_main_space_heating_system_1,
efficiency_of_main_space_heating_system_2,
efficiency_of_secondary_space_heating_system,
cooling_system_energy_efficiency_ratio_table_10c,
space_heating_requirement_monthly,
output_from_water_heater_monthly,
water_heater_type,
efficiency_of_water_heater,
efficiency_of_water_heater_adjustment_table_4c,
space_cooling_requirement_monthly,
electricity_demand_mechanical_ventilation_fans_table_4f,
electricity_demand_warm_air_heating_systems_fans_table_4f,
electricity_demand_central_heating_pump_or_water_pump_table_4f,
electricity_demand_oil_boiler_pump_table_4f,
electricity_demand_boiler_flue_fan_table_4f,
electricity_demand_keep_hot_facility_gas_combi_boiler_table_4f,
electricity_demand_pump_for_solar_water_heating_table_4f,
electricity_demand_pump_for_storage_WWHRSTable_G3,
annual_lighting_demand,
electricity_generated_by_PV_appendix_M,
electricity_generated_by_wind_turbine_appendix_M,
electricity_used_or_generated_by_micro_CHP_appendix_N,
electricity_generated_by_hydro_electric_generator_appendix_Q,
appendix_Q_energy_saved,
appendix_Q_energy_used)

Calculates Energy Requirements, Section 9a.

Parameters

- **fraction_of_space_heat_secondary_system** (*float*) – See (201).
- **fraction_of_space_heat_from_main_system_2** (*float*) – See (202).
- **efficiency_of_main_space_heating_system_1** (*float*) – See (206).
- **efficiency_of_main_space_heating_system_2** (*float*) – See (207).
- **efficiency_of_secondary_space_heating_system** (*float*) – See (208).

- **cooling_system_energy_efficiency_ratio_table_10c** (*list of floats*) – See (209).
- **space_heating_requirement_monthly** (*list of floats*) – See (211).
- **output_from_water_heater_monthly** (*list of floats*) – See (216).
- **efficiency_of_water_heater_table_4a** (*float*) – See (216).
- **space_cooling_requirement_monthly** (*list of floats*) – See (219).
- **electricity_demand_mechanical_ventilation_fans_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_warm_air_heating_systems_fans_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_central_heating_pump_or_water_pump_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_oil_boiler_pump_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_boiler_flue_fan_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_keep_hot_facility_gas_combi_boiler_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_pump_for_solar_water_heating_table_4f** (*float*) – See (230) in kWh/yr.
- **electricity_demand_pump_for_storage_WWHRs_Table_G3** (*float*) – See (230) in kWh/yr.
- **electricity_for_lighting** (*float*) – See (232) in kWh/yr.
- **electricity_generated_by_PV_appendix_M** (*float*) – See (233) in kWh/yr.
- **electricity_generated_by_wind_turbine_appendix_M** (*float*) – See (234) in kWh/yr.
- **electricity_used_or_generated_by_micro_CHP_appendix_N** (*float*) – See (235) in kWh/yr.
- **electricity_generated_by_hydro_electric_generator,appendix_M** (*float*) – See (235) in kWh/yr.
- **appendix_Q_energy_saved** (*float*) – See (236) in kWh/yr.
- **appendix_Q_energy_used** (*float*) – See (237) in kWh/yr.

Returns

A dictionary with keys of (fraction_of_space_heat_from_main_systems, fraction_of_total_space_heat_from_main_system_1, fraction_of_total_space_heat_from_main_system_2, space_heating_fuel_main_system_1, space_heating_fuel_main_system_2, space_heating_fuel_secondary_system, efficiency_of_water_heater_table_4a, fuel_for_water_heating_monthly, space_cooling_fuel_monthly, space_heating_fuel_used_main_system_1, space_heating_fuel_used_main_system_2, space_heating_fuel_used_secondary, water_fuel_used, space_cooling_fuel_used, electricity_for_pumps_fans_electric_keep_hot, energy_saving_generation_technologies_total, appendix_Q_energy_total, energy_for_lighting, total_energy_used)

- **fraction_of_space_heat_from_main_systems** (*float*):
- **fraction_of_total_space_heat_from_main_system_1** (*float*):

- **`fraction_of_total_space_heat_from_main_system_2`** (`float`):
- **`space_heating_fuel_main_system_1`** (`list (float)`): See (211) in kWh/month.
- **`space_heating_fuel_main_system_2`** (`list (float)`): See (213) in kWh/month.
- **`space_heating_fuel_main_system_secondary_system`** (`list (float)`): See (214) in kWh/month.
- **`fuel_for_water_heating_monthly`** (`list (float)`): See (219) in kWh/month.
- **`space_cooling_fuel_monthly`** (`list (float)`): See (221) in kWh/month.
- **`space_heating_fuel_used_main_system_1`** (`float`): See (211) in kWh/yr.
- **`space_heating_fuel_used_main_system_2`** (`float`): See (213) in kWh/yr.
- **`space_heating_fuel_used_secondary`** (`float`): See (215) in kWh/yr.
- **`water_fuel_used`** (`float`): See (219) in kWh/yr.
- **`space_cooling_fuel_used`** (`float`): See (221) in kWh/yr.
- **`electricity_for_pumps_fans_electric_keep_hot`** (`float`): See (230) in kWh/yr.
- **`energy_saving_generation_technologies`** (`float`): See (230) in kWh/yr.
- **`appendix_Q_energy`** (`float`): See (237) in kWh/yr.
- **`total_energy_used`** (`float`): See (237) in kWh/yr.

Return type`dict`

10. FUEL COSTS

```
sap2012.SAP_worksheet.fuel_costs.fuel_costs(space_heating_fuel_used_main_system_1,  
space_heating_fuel_used_main_system_2,  
space_heating_fuel_used_secondary,  
space_heating_fuel_price_main_system_1,  
space_heating_fuel_price_main_system_2,  
space_heating_fuel_price_secondary,  
water_heating_high_rate_fraction_table_13,  
water_heating_low_rate_fraction_table_13,  
high_rate_fuel_price, low_rate_fuel_price,  
water_fuel_used, water_heating_fuel_price_other,  
space_cooling_fuel_used, space_cooling_fuel_price,  
electricity_for_pumps_fans_electric_keep_hot,  
fuel_price_for_pumps_fans_electric_keep_hot,  
energy_for_lighting, fuel_price_for_lighting,  
additional_standing_charges_table_12,  
energy_saving_generation_technologies,  
energy_saving_generation_technologies_fuel_price,  
appendix_Q_energy_used,  
appendix_Q_energy_used_fuel_price,  
appendix_Q_energy_saved,  
appendix_Q_energy_saved_fuel_price)
```

Calculates Fuel Costs, Section 10.

Table 12 is used for fuel price factors.

Parameters

- **space_heating_fuel_main_system_1** (*float*) – See (211) in kWh/year.
- **space_heating_fuel_main_system_2** (*float*) – See (212) in kWh/year.
- **space_heating_fuel_secondary** (*float*) – See (213) in kWh/year.
- **space_heating_fuel_price_main_system_1** (*float*) – See (240) in £/kWh.
- **space_heating_fuel_price_main_system_2** (*float*) – See (241) in £/kWh.
- **space_heating_fuel_price_secondary** (*float*) – See (242) in £/kWh.
- **water_heating_high_rate_fraction_table_13** (*float*) – See (243) in £/kWh.
- **water_heating_low_rate_fraction_table_13** (*float*) – See (244) in £/kWh.
- **high_rate_fuel_price** (*float*) – See (245) in £/kWh.
- **low_rate_fuel_price** (*float*) – See (246) in £/kWh.

- **water_fuel_used** (*float*) – See (219) in kWh/year.
- **water_heating_fuel_price_other** (*float*) – See (247) in £/kWh.
- **space_cooling_fuel_used** (*float*) – See (248) in kWh/year.
- **space_cooling_fuel_price** (*float*) – See (248) in £/kWh.
- **electricity_for_pumps_fans_electric_keep_hot** (*float*) – See (249) in kWh/year.
- **fuel_price_for_pumps_fans_electric_keep_hot** (*float*) – See (249) in £/kWh.
- **energy_for_lighting** (*float*) – See (231) in kWh/year.
- **fuel_price_for_lighting** (*float*) – See (250) in £/kWh.
- **additional_standing_charges_table_12** (*float*) – See (251) in £/kWh.
- **energy_saving_generation_technologies** (*float*) – See (252) in kWh/year.
- **energy_saving_generation_technologies_fuel_price** (*float*) – See (252) in £/kWh.
- **appendix_Q_energy_used** (*float*) – See (253) in kWh/year.
- **appendix_Q_energy_used_fuel_price** (*float*) – See (253) in £/kWh.
- **appendix_Q_energy_saved** (*float*) – See (254) in kWh/year.
- **appendix_Q_energy_saved_fuel_price** (*float*) – See (254) in £/kWh.

Returns

A dictionary with keys of (space_heating_main_system_1_fuel_cost, space_heating_main_system_2_fuel_cost, space_heating_secondary_fuel_cost, water_heating_high_rate_fuel_cost, water_heating_low_rate_fuel_cost, water_heating_cost_other, space_cooling_cost, pumps_fan_keep_hot_cost, lighting_cost, appendix_Q_fuel_cost, energy_saving_total_fuel_cost, additional_standing_charges_table_12, total_fuel_cost)

- **space_heating_main_system_1_fuel_cost** (*float*): See (240) in £/year.
- **space_heating_main_system_2_fuel_cost** (*float*): See (241) in £/year.
- **space_heating_secondary_fuel_cost** (*float*): See (242) in £/year.
- **water_heating_high_rate_fuel_cost** (*float*): See (245) in £/year.
- **water_heating_low_rate_fuel_cost** (*float*): See (246) in £/year.
- **water_heating_cost_other** (*float*): See (247) in £/year.
- **space_cooling_cost** (*float*): See (248) in £/year.
- **pumps_fan_keep_hot_cost** (*float*): See (249) in £/year.
- **lighting_cost** (*float*): See (250) in £/year.
- **appendix_Q_used_fuel_cost** (*float*): See (253) in £/year.
- **appendix_Q_saved_fuel_cost** (*float*): See (254) in £/year.
- **energy_saving_generation_technologies_fuel_cost** (*float*): See (252) in £/year.
- **appendix_Q_fuel_cost** (*float*): in £/year.
- **energy_saving_total_fuel_cost** (*float*): in £/year.
- **total_fuel_cost** (*float*): See (255) in £/year.

Return type
dict

11. SAP RATING

`sap2012.SAP_worksheet.SAP_rating.SAP_rating(energy_cost_deflator, total_fuel_cost, total_floor_area)`

Calculates SAP rating, Section 11.

Parameters

- **energy_cost_deflator** (*float*) – See (256). Found in Table 12.
- **total_energy_cost** (*float*) – See (255) in £.
- **total_floor_area** (*float*) – in m2.

Returns

A dictionary with keys of (*energy_cost_factor*, *SAP_rating_value*)

- **energy_cost_factor** (*float*): See (257)
- **SAP_rating_value** (*float*): See (258)

Return type

dict

12. CO2 EMISSIONS

```
sap2012.SAP_worksheet.CO2_emissions.CO2_emissions(space_heating_fuel_used_main_system_1,  
                                                    space_heating_fuel_used_main_system_2,  
                                                    space_heating_fuel_used_secondary,  
                                                    space_heating_fuel_emission_factor_main_system_1,  
                                                    space_heating_fuel_emission_factor_main_system_2,  
                                                    space_heating_fuel_emission_factor_secondary,  
                                                    water_fuel_used,  
                                                    water_heating_fuel_emission_factor,  
                                                    space_cooling_fuel_used,  
                                                    space_cooling_fuel_emission_factor,  
                                                    electricity_for_pumps_fans_electric_keep_hot,  
                                                    fuel_emission_factor_for_pumps_fans_electric_keep_hot,  
                                                    energy_for_lighting,  
                                                    fuel_emission_factor_for_lighting,  
                                                    energy_saving_generation_technologies, en-  
                                                    energy_saving_generation_technologies_fuel_emission_factor,  
                                                    appendix_Q_energy_used,  
                                                    appendix_Q_energy_used_fuel_emission_factor,  
                                                    appendix_Q_energy_saved,  
                                                    appendix_Q_energy_saved_fuel_emission_factor,  
                                                    total_floor_area)
```

Calculates CO2 emissions, Section 12.

Table 12 is used for fuel emission factors.

Parameters

- **space_heating_fuel_main_system_1** (*float*) – See (211) in kWh/year.
- **space_heating_fuel_main_system_2** (*float*) – See (212) in kWh/year.
- **space_heating_fuel_secondary** (*float*) – See (213) in kWh/year.
- **space_heating_fuel_emission_factor_main_system_1** (*float*) – See (261) in kg CO2/kWh.
- **space_heating_fuel_emission_factor_main_system_2** (*float*) – See (262) in kg CO2/kWh.
- **space_heating_fuel_emission_factor_secondary** (*float*) – See (263) in kg CO2/kWh.
- **water_fuel_used** (*float*) – in kWh/year.
- **water_heating_fuel_emission_factor** (*float*) – See (264) in kg CO2/kWh.

- **space_cooling_fuel_used** (*float*) – in kWh/year.
- **space_cooling_fuel_emission_factor** (*float*) – See (266) in kg CO2/kWh.
- **electricity_for_pumps_fans_electric_keep_hot** (*float*) – in kWh/year.
- **fuel_emission_factor_for_pumps_fans_electric_keep_hot** (*float*) – See (267) in kg CO2/kWh.
- **energy_for_lighting** (*float*) – in kWh/year.
- **fuel_emission_factor_for_lighting** (*float*) – See (268) in kg CO2/kWh.
- **space_cooling_fuel_used** – in kWh/year.
- **energy_saving_generation_technologies** (*float*) – in kWh/year.
- **energy_saving_generation_technologies_fuel_emission_factor** (*float*) – See (269) in kg CO2/kWh.
- **appendix_Q_energy_used** (*float*) – in kWh/year.
- **appendix_Q_energy_used_fuel_emission_factor** (*float*) – See (270) in kg CO2/kWh.
- **appendix_Q_energy_saved** (*float*) – in kWh/year.
- **appendix_Q_energy_saved_fuel_emission_factor** (*float*) – See (271) in kg CO2/kWh.
- **total_floor_area** (*float*) – in m2.

Returns

A dictionary with keys of (space_heating_main_system_1_emissions, space_heating_main_system_2_emissions, space_heating_secondary_emissions, water_used_emissions, space_cooling_used_emissions, pumps_fans_electric_keep_hot_emissions, lighting_emissions, appendix_Q_used_emissions, appendix_Q_saved_emissions, energy_saving_generation_technologies_emissions, space_and_water_heating_emissions, appendix_Q_total_used_emissions, appendix_Q_total_saved_emissions, energy_saving_generation_technologies_total_emissions, total_CO2_emissions_yearly, dwelling_CO2_emission_rate, CF, EI_rating)

- **space_heating_main_system_1_emissions** (*float*): See (261) in kg CO2/yr.
- **space_heating_main_system_2_emissions** (*float*): See (262) in kg CO2/yr.
- **space_heating_secondary_emissions** (*float*): See (263) in kg CO2/yr.
- **water_used_emissions** (*float*): See (264) in kg CO2/yr.
- **space_cooling_used_emissions** (*float*): See (266) in kg CO2/yr.
- **pumps_fans_electric_keep_hot_emissions** (*float*): See (267) in kg CO2/yr.
- **lighting_emissions** (*float*): See (268) in kg CO2/yr.
- **appendix_Q_used_emissions** (*float*): See (270) in kg CO2/yr.
- **appendix_Q_saved_emissions** (*float*): See (271) in kg CO2/yr.
- **energy_saving_generation_technologies_emissions** (*float*): See (269) in kg CO2/yr.
- **space_and_water_heating_emissions** (*float*): See (265) in kg CO2/yr.
- **appendix_Q_total_used_emissions** (*float*): in kg CO2/yr.
- **appendix_Q_total_saved_emissions** (*float*): in kg CO2/yr.

- **energy_saving_generation_technologies_total_emissions** ([float](#)): in kg CO2/yr.
- **total_CO2_emissions_yearly** ([float](#)): See (272) in kg CO2/yr.
- **dwelling_CO2_emission_rate** ([float](#)): See (273) in kg CO2/m2/yr.
- **CF** ([float](#)):
- **EI_rating** ([float](#)): See (274).

Return type[dict](#)

INTERNAL_GAINS_APPENDIX_L FUNCTION

```
sap2012.SAP_appendices.internal_gains_appendix_L.internal_gains_appendix_L(total_floor_area,  
                                                                           as-  
                                                                           sumed_occupancy,  
                                                                           num-  
                                                                           ber_of_low_energy_light_bulbs,  
                                                                           to-  
                                                                           tal_number_of_light_bulbs,  
                                                                           frame_factor,  
                                                                           window_area,  
                                                                           light_access_factor_table_6d,  
                                                                           light_transmittance_factor_table_6d,  
                                                                           month_number,  
                                                                           days_in_month,  
                                                                           heat_gains_from_water_heating_mon)
```

Internal gain calculations as given in Appendix L.

Parameters

- **total_floor_area** (*float*) – See (4).
- **assumed_occupancy** (*float*) – See (42). Calculated using equation from (42). If TFA > 13.9, $N = 1 + 1.76 * [1 - \exp(-0.000349 * (TFA - 13.9)^2)] + 0.0013 * (TFA - 13.9)$. if TFA ≤ 13.9, N = 1. Where TFA is the Total Floor Area.
- **number_of_low_energy_light_bulbs** (*int*) –
- **total_number_of_light_bulbs** (*int*) –
- **frame_factor** (*float*) –
- **window_area** (*float*) –
- **light_access_factor_table_6d** (*float*) –
- **light_transmittance_factor_table_6d** (*float*) –
- **month_number** (*list(int)*) –
- **days_in_month** (*float(int)*) – List of the number of days in each month of the calendar year.
- **heat_gains_from_water_heating_monthly** (*list(float)*) –
(65) in kWh/month.

Returns

A dictionary with keys of (G_L, C_1, C_2, E_B, initial_annual_lighting_demand,

```
monthly_lighting_demand,      annual_lighting_demand,      lighting_gains,      ini-  
tial_annual_electrical_appliance_demand,      monthly_electrical_appliance_demand,      an-  
nual_electrical_appliance_demand,      appliances_gains,      cooking_gains,      losses,      wa-  
ter_heating_gains, metabolic_gains )
```

- **G_L** (float)-
- **C_1** (float)-
- **C_2** (float)-
- **E_B** (float)-
- **initial_annual_lighting_demand** (float)-
- **monthly_lighting_demand** (list (float))-
- **annual_lighting_demand** (float)-
- **lighting_gains** (list (float))-
- **initial_annual_electrical_appliance_demand** (float)-
- **monthly_electrical_appliance_demand** (list (float))-
- **annual_electrical_appliance_demand** (float)-
- **appliances_gains** (list (float))-
- **cooking_gains** (list (float))-
- **losses** (list (float))-
- **water_heating_gains** (list (float))-
- **metabolic_gains** (list (float))-

Return type

dict

SOLAR_GAINS_APPENDIX_U3 FUNCTION

`sap2012.SAP_appendices.solar_gains_appendix_U3.solar_gains_appendix_U3(solar_radiation_horizontal_plane_monthly,`
`so-`
`lar_declination_monthly_table_U3,`
`loca-`
`tion_latitude_table_U4,`
`p_tilt)`

Solar gains calculations as given in Appendix U3.

Parameters

- `solar_radiation_horizontal_plane_monthly_table_U3` (`list(float)`) –
- `solar_declination_monthly_table_U3` (`list(float)`) –
- `location_latitude_table_U4` (`float`) –
- `p_tilt` (`float`) –

Returns

A dictionary with keys of (`solar_flux_north`, `solar_flux_north_east`, `solar_flux_east`, `solar_flux_south_east`, `solar_flux_south`, `solar_flux_south_west`, `solar_flux_west`, `solar_flux_north_west`)

- `solar_flux_north` (`list(float)`) -
- `solar_flux_north_east` (`list(float)`) -
- `solar_flux_east` (`list(float)`) -
- `solar_flux_south_east` (`list(float)`) -
- `solar_flux_south` (`list(float)`) -
- `solar_flux_south_west` (`list(float)`) -
- `solar_flux_west` (`list(float)`) -
- `solar_flux_north_west` (`list(float)`) -

Return type

`dict`

UTILISATION_FACTOR_FOR_HEATING_TABLE_9A FUNCTION

sap2012.SAP_tables.utilisation_factor_for_heating_table_9a.utilisation_factor_for_heating_table_9a(heat_

to-
tal_in
tem-
per-
a-
ture_
heat-
ing_c
month
ther-
mal_
heat_

Utilisation factor calculations for heating from Table 9a.

Parameters

- **heat_transfer_coefficient** (*list(float)*) – See (39), in W/K.
- **total_internal_and_solar_gains** (*list(float)*) – See (84) in W.
- **temperature_during_heating_living_room** (*float*) –
- **heating_controls** (*int*) –
- **monthly_external_temperature_table_U1** (*list(float)*) –
- **thermal_mass_parameter** (*float*) – See (35), in kJ/m²K.
- **heat_loss_parameter** (*list(float)*) – See (40), in W/m²K.

Returns

A dictionary with keys of (time_constant, a, heat_loss_rate_living_room, y_living_room, utilisation_factor_for_heating_living_room, temperature_during_heating_rest_of_dwelling, heat_loss_rate_rest_of_dwelling, y_rest_of_dwelling, utilisation_factor_for_heating_rest_of_dwelling)

- **time_constant** (*list(float)*) -
- **a** (*list(float)*) -
- **heat_loss_rate_living_room** (*list(float)*) -
- **y_living_room** (*list(float)*) -
- **utilisation_factor_for_heating_living_room** (*list(float)*) -
- **temperature_during_heating_rest_of_dwelling** (*list(float)*) -

- `heat_loss_rate_rest_of_dwelling (list (float))` -
- `y_rest_of_dwelling (list (float))` -
- `utilisation_factor_for_heating_rest_of_dwelling (list (float))` -

Return type

`dict`

UTILISATION_FACTOR_FOR_HEATING_WHOLE_HOUSE_TABLE_9A FUNCTION

`sap2012.SAP_tables.utilisation_factor_for_heating_whole_house_table_9a.utilisation_factor_for_heating_w`

Utilisation factor calculations for heating from Table 9a.

Parameters

- `heat_transfer_coefficient` (*list(float)*) – See (39), in W/K.
- `total_internal_and_solar_gains` (*list(float)*) – See (84) in W.
- `mean_internal_temp_whole_dwelling` (*float*) – See (92) in degC.
- `monthly_external_temperature_table_U1` (*list(float)*) –
- `thermal_mass_parameter` (*float*) – See (35), in kJ/m²K.
- `heat_loss_parameter` (*list(float)*) – See (40), in W/m²K.

Returns

A dictionary with keys of (`time_constant_whole_house`, `a_whole_house`, `heat_loss_rate_whole_house`, `y_whole_house`, `utilisation_factor_for_heating_whole_house`)

- `time_constant_whole_house` (*list(float)*) -
- `a_whole_house` (*list(float)*) -
- `heat_loss_rate_whole_house` (*list(float)*) -
- `y_whole_house` (*list(float)*) -
- `utilisation_factor_for_heating_whole_house` (*list(float)*) -

Return type

`dict`

TEMPERATURE_REDUCTION_WHEN_HEATING_IS_OFF_TABLE_9B FUNCTION

`sap2012.SAP_tables.temperature_reduction_when_heating_is_off_table_9b.temperature_reduction_when_heating_is_off_table_9b`

Calculates temperature reduction as given in Table 9b.

Parameters

- `time_constant` (*list(float)*) –
- `hours_heating_is_off_1_weekday_living_room` (*float*) –

- `hours_heating_is_off_2_weekday_living_room` (*float*) –
- `hours_heating_is_off_1_weekend_living_room` (*float*) –
- `hours_heating_is_off_2_weekend_living_room` (*float*) –
- `hours_heating_is_off_1_weekday_rest_of_dwelling` (*float*) –
- `hours_heating_is_off_2_weekday_rest_of_dwelling` (*float*) –
- `hours_heating_is_off_1_weekend_rest_of_dwelling` (*float*) –
- `hours_heating_is_off_2_weekend_rest_of_dwelling` (*float*) –
- `temperature_during_heating_living_room` (*float*) –
- `temperature_during_heating_rest_of_dwelling` (*list(float)*) –
- `responsiveness_of_heating_system` (*float*) –
- `monthly_external_temperature_table_U1` (*list(float)*) –
- `utilisation_factor_for_heating_living_room` (*list(float)*) –
- `utilisation_factor_for_heating_rest_of_dwelling` (*list(float)*) –
- `heat_transfer_coefficient` (*list(float)*) – See (39), in W/K.
- `total_internal_and_solar_gains` (*list(float)*) – See (84) in W.

Returns

A dictionary with keys (`t_c`, `internal_temperature_without_heating_living_room`, `internal_temperature_without_heating_rest_of_dwelling`, `temperature_reduction_when_heating_is_off_1_weekday_living_room`, `temperature_reduction_when_heating_is_off_2_weekday_living_room`, `temperature_reduction_when_heating_is_off_1_weekend_living_room`, `temperature_reduction_when_heating_is_off_2_weekend_living_room`, `temperature_reduction_when_heating_is_off_1_weekday_rest_of_dwelling`, `temperature_reduction_when_heating_is_off_2_weekday_rest_of_dwelling`, `temperature_reduction_when_heating_is_off_1_weekend_rest_of_dwelling`, `temperature_reduction_when_heating_is_off_2_weekend_rest_of_dwelling`)

- `t_c` (*list(float)*) –
- `internal_temperature_without_heating_living_room` (*list(float)*) –
- `internal_temperature_without_heating_rest_of_dwelling` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_1_weekday_living_room` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_2_weekday_living_room` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_1_weekend_living_room` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_2_weekend_living_room` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_1_weekday_rest_of_dwelling` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_2_weekday_rest_of_dwelling` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_1_weekend_rest_of_dwelling` (*list(float)*) –
- `temperature_reduction_when_heating_is_off_2_weekend_rest_of_dwelling` (*list(float)*) –

Return type

`dict`

HEATING_REQUIREMENT_TABLE_9C FUNCTION

```
sap2012.SAP_tables.heating_requirement_table_9c.heating_requirement_table_9c(temperature_reduction_when_heating_is_off_1_weekday_living_room,
temperature_reduction_when_heating_is_off_2_weekday_living_room,
temperature_reduction_when_heating_is_off_1_weekend_living_room,
temperature_reduction_when_heating_is_off_2_weekend_living_room,
temperature_reduction_when_heating_is_off_1_weekday_rest_of_dwelling,
temperature_reduction_when_heating_is_off_2_weekday_rest_of_dwelling,
temperature_reduction_when_heating_is_off_1_weekend_rest_of_dwelling,
temperature_during_heating_living_room,
temperature_during_heating_rest_of_dwelling,
temperature_adjustment_table_4e)
```

Calculates the heating requirement as given in Table 9c.

Parameters

- **temperature_reduction_when_heating_is_off_1_weekday_living_room**
(list(float)) –
- **temperature_reduction_when_heating_is_off_2_weekday_living_room**
(list(float)) –
- **temperature_reduction_when_heating_is_off_1_weekend_living_room**
(list(float)) –
- **temperature_reduction_when_heating_is_off_2_weekend_living_room**
(list(float)) –
- **temperature_reduction_when_heating_is_off_1_weekday_rest_of_dwelling**
(list(float)) –
- **temperature_reduction_when_heating_is_off_2_weekday_rest_of_dwelling**
(list(float)) –
- **temperature_reduction_when_heating_is_off_1_weekend_rest_of_dwelling**
(list(float)) –

- `temperature_reduction_when_heating_is_off_2_weekend_rest_of_dwelling` (`list(float)`) -
- `temperature_during_heating_living_room` (`float`) -
- `temperature_during_heating_rest_of_dwelling` (`list(float)`) -
- `temperature_adjustment_table_4e` (`float`) -

Returns

A dictionary with keys (`T_weekday_living_room`, `T_weekend_living_room`, `mean_internal_temperature_living_room_T1_Table_9c`, `T_weekday_rest_of_dwelling`, `T_weekend_rest_of_dwelling`, `mean_internal_temperature_rest_of_dwelling_T2_table_9c`)

- `T_weekday_living_room` (`list(float)`) -
- `T_weekend_living_room` (`list(float)`) -
- `mean_internal_temperature_living_room_T1_Table_9c` (`list(float)`) -
- `T_weekday_rest_of_dwelling` (`list(float)`) -
- `T_weekend_rest_of_dwelling` (`list(float)`) -
- `mean_internal_temperature_rest_of_dwelling_T2_table_9c` (`list(float)`) -

Return type

`dict`

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