Power Proportional Distribution (PPD)

Application Note
# Table of Contents

1. Description ............................................................................................................................................... 3

2. Application and Design .......................................................................................................................... 3
   2.1 PPD Application with an intelligent Touch Controller™ (iTC) ......................................................... 5
   2.2 PPD Application with intelligent Touch Manager™ (iTM) ............................................................. 6

3. Setup and Commissioning ..................................................................................................................... 7

4. PPD Calculation Results and Billing ...................................................................................................... 7

5. Exclusions ................................................................................................................................................. 7

6. PPD Calculation Logic ............................................................................................................................. 8
   6.1 Logic 1: Thermo-load .................................................................................................................... 8
   6.2 Logic 2: Partial Off ......................................................................................................................... 9
   6.3 Logic 3: All Off .............................................................................................................................. 10

7. Accessing PPD Data Results ................................................................................................................. 12
   7.1 Accessing PPD Results Data from the intelligent Touch Controller™ ............................................. 12
   7.2 Accessing PPD Results Data from the intelligent Touch Manager™ ............................................. 14

8. Summary ................................................................................................................................................ 15
1. Description

The Power Proportional Distribution (PPD) feature provides the user with a reasonably calculated apportionment of the total power consumption by the Daikin individual indoor units in the VRV system.

The intent of the PPD function is to apportion total outdoor unit power consumption back into the respective indoor units that are served by those outdoor units. In other words, for each indoor unit that is exchanging heat, either in the cooling mode or heating mode, its operation is supported by a condensing unit that is consuming energy. The PPD function mathematically calculates each indoor unit portion of that outdoor unit total power consumption based upon its return air temperature, electronic expansion valve position and baseline values determined by the factory.

2. Application and Design

The quantity and specification for the energy meter on a PPD project will depend upon the equipment type, the expectation for PPD results and the configuration of the line voltage electrical wiring that is servicing the VRV condensing units.

To control costs and reduce overall complexity, the optimum situation is the application of the energy meter to the electrical distribution panel (breaker panel) that is serving the Daikin outdoor units. In this case, the overall power consumption of several outdoor units can be captured by a single energy meter—a reduction of cost, installation and commissioning complexity. The caveat to this approach is the requirement of that the panel in question must not serve any other equipment or ancillary devices in the facility. Otherwise, the energy meter would have to be specified and applied to each individual outdoor unit. It is highly recommended that project managers and project engineers consider the electrical distribution system design at the earliest stages of project design to ensure that deployment, installation and commissioning of the equipment is feasible and within reasonable budget allowances. PPD and the accompanying hardware and software requirements are multi-tenant billing solution that demands an acute engineering focus.
The power consumption of the indoor units is not considered in the PPD results unless it is specifically required that this information is incorporated into the PPD solution. In this case, the kWh meters would again be required on the panel(s) serving ONLY the indoor units. Otherwise, it is generally assumed that the indoor unit power consumption (which is relatively insignificant unless you are applying high CFM ducted units) is captured as part of the tenant sub-metering for internal power consumption (i.e. lights, plugs, appliances.)

The outdoor units for Daikin VRV systems can be provided power from the same electrical distribution panel from a PPD perspective unless the owner requires capabilities for benchmarking performance from the range of technology applied on his project. This rule does not supersede or otherwise modify the electrical requirements as mandated by national, state and local codes. Primary electrical system design principals still apply and take precedence over any guidance regards to the PPD functions.
2.1 PPD Application with an intelligent Touch Controller™ (iTC)

The intelligent Touch Controller (DCS601C71) is a multi-zone controller that monitors and controls the Daikin VRV indoor units. The iTC can natively accommodate up to three pulse inputs. 3 additional inputs are available when the DIII-Net Plus Adapter (DCS601A72) is added to the iTC.

The pulse output provided by the energy meters terminates directly to the pulse input terminals on the iTC or the DIII-Net Plus Adapter. In most applications, these energy meters must be measuring the energy consumption from condensing units that are serving indoor units and under the management of the iTC. In the case of having several condensing units on the project, it is possible to sub-meter the entire panel that is serving those condensing units as long as:

1) There are no other devices being served by the electrical distribution panel.
2) The condensing units are serving refrigerant to the indoor units that are under the iTC management and receiving that energy meters pulse input.

Internal PPD results are stored within the iTC for up to 12 months. The PPD data can be downloaded to a PC when the users log in remotely to the iTC’s web browsing option (DCS004A71) or can be downloaded to a PCMCIA memory card when the user exports the file through the PPD menu on the iTC itself.

The pulse output from the energy meter must meet the iTC requirements:
- The pulse wire should be 18-16AWG and up to 492ft (150m) between the energy meter and PI terminal on the iTC.
- The pulse output type is non-voltage, normally open, momentary contact closure. This is usually a semiconductor switched output. On the Square-D PowerLogic series energy meters it is referred to as an Opto-FET output. (Non-mechanical relay type. FET is a Field Effect Transistor).
- The pulse output of 1 pulse per 1 kWh or 1 pulse per 10kWh.
- The pulse output width must range from 40 to 40msec.
- The pulse output interval must be 100 milliseconds or more.

![Fig 3. Energy meter pulse specification for iTC](image-url)
2.2 PPD Application with intelligent Touch Manager™ (iTM)

The intelligent Touch Manager is an advanced multi-zone controller that monitors and control Daikin VRV indoor units. The iTM can natively accommodate up to three pulse inputs. That number rises to 31 pulse inputs when up to 7 iTM Plus Adapters (DCM601A72) are added to the iTM. Each iTM Plus Adapter has four pulse inputs that can be used to connect kWh meters.

The pulse output provided by the energy meters terminates directly to the pulse input terminals on the iTM or the iTM Plus Adapter. These energy meters must be measuring the energy consumption from condensing units that are serving indoor units and under the management of the iTM. In the case of having several condensing units on the project, it is possible to sub-meter the entire panel that is serving those condensing units as long as:

1) There are no other devices being served by the electrical distribution panel.
2) The condensing units are serving refrigerant to the indoor units that are under the iTM management and receiving that energy meters pulse input.

The PPD data can be downloaded to a PC when the users log in remotely to the iTM’s web browsing or can be downloaded to a USB card when the user exports the CSV file from the PPD menu on the iTM itself. The PPD data output can be customized using the PPD Calculation Tool to provide a simpler format of the energy usage bill.

The pulse output from the energy meter must meet the iTM requirements:
- The pulse wire should be 22-19 AWG and up to 656ft (200m) between the energy meter and PI terminal on the iTM.
- The pulse output type is non-voltage, normally open, momentary contact closure. This is usually a semiconductor switched output. On the Square D PowerLogic series energy meters it is referred to as an Opto-FET output. (Non-mechanical relay type. FET is a Field Effect Transistor).
- Must provide an output of 1 pulse per 0.1kWh or 1 pulse per 1kWh or 1 pulse per 10kWh.
- The pulse output width must have a duration or width of 20 – 400 milliseconds.
- The pulse output interval must be 100 milliseconds or more.

![Fig 4. Energy meter pulse specification for iTM](image)

The following meters have been tested and approved:
2. SATEC EM-133 (Approved by New York State department of public service as of 03/2017). The SATEC EM-133 will require parameters configuration using SATEC PAC software. More information can be found here: [http://www.satec-global.com/EM133](http://www.satec-global.com/EM133)
3. Setup and Commissioning

Configuration and commissioning of PPD when applied with either the intelligent Touch Controller or the intelligent Touch Manager are facilitated by Daikin Service team or approved service personnel.

4. PPD Calculation Results and Billing

The PPD results will not include the indoor unit’s power consumption, which would include the fan of the indoor unit and the power consumed by the onboard electronics. It is generally assumed that this power consumption is accounted for in the tenants or end-users sub-metered power for their internal usage. However, it is a PPD option to sub-meter the indoor unit power consumption and include the pulses in the power group configuration of the software. With this approach, the PPD results will include both outdoor and indoor units. Just remember that the PPD output results CSV files (comma separated values) will not be inclusive of indoor unit power consumption unless the indoor units have been specifically sub-metered with the pulse inputs having been configured in the power group setups.

The facility manager should be aware that they will get relatively raw data output as a result of PPD data retrieval. This means a series of CSV files indicating individual indoor units and their respective watt-hour power consumption data over various blocks of time. Organization, formatting, compilation and presentation of this data in a billable format is the sole responsibility of the building owner.

5. Exclusions

1. The PPD technology is not compatible with the Daikin family of RA and RA Multi (single-split and multi-split) air conditioning heat pump products.
2. Daikin does not make any claims to or guarantees of any specific metric of performance or accuracy of the PPD technology as the variable nature of installation integrity, quality (field installation) and conformance to design requirements (VRV system application and engineering) can vary significantly from project to project and are often outside the control of Daikin North America.
6. PPD Calculation Logic

Daikin’s PPD software improves upon the common billing methods of unit square footage or simple run-time by using the fan coil’s actual operational parameters to determine the indoor unit’s capacity relative to the other units on a shared condensing unit system. The software uses the unit size, refrigerant expansion valve position (how far open) to measure the refrigerant flow, in tandem with the operational temperature feedback to determine the unit’s capacity. The relative capacities are then used to proportionally allocate the condensing unit’s power consumption. The below example shows how the heat load calculation (PPD calculations) provides accurate energy consumption per indoor unit in comparison to energy consumption based on floor size or energy consumption based on operation hours.

The PPD software calculates the energy consumption every 20 seconds and only records the data once each hour using 3 different types of logics: thermo load; partial off and all off.

6.1 Logic 1: Thermo- load

The indoor unit heat load is calculated every 20 sec for each indoor unit based on:

1. The indoor unit size (nominal capacity):
   The larger the fan coil, the more capacity it will have as the system loads up.

<table>
<thead>
<tr>
<th>Tenant A</th>
<th>Tenant B</th>
<th>Tenant C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit Size</strong></td>
<td>4 tons</td>
<td>4 tons</td>
</tr>
<tr>
<td><strong>Room Temp</strong></td>
<td>80°F</td>
<td>73°F</td>
</tr>
<tr>
<td><strong>Room Setpoint</strong></td>
<td>72°F</td>
<td>72°F</td>
</tr>
<tr>
<td><strong>EEV Thermo Steps</strong></td>
<td>700 pulses (100% open)</td>
<td>200 pulses (28% open)</td>
</tr>
<tr>
<td><strong>Calculated Thermo Load</strong></td>
<td>48K btu/hr</td>
<td>30.2K btu/hr</td>
</tr>
<tr>
<td><strong>Allocated kWh based on heat load</strong></td>
<td>48K btu/hr x 100 kWh</td>
<td>30.2K btu/hr x 100 kWh</td>
</tr>
<tr>
<td>(48+30.2+15.1)K btu/hr</td>
<td>51 kWh</td>
<td>32 kWh</td>
</tr>
<tr>
<td><strong>Floor Size</strong></td>
<td>2000 Sq.ft.</td>
<td>2000 Sq.ft.</td>
</tr>
<tr>
<td><strong>Allocated kWh based on floor size</strong></td>
<td>2000sq ft/5000sq ft x 100 kWh = 40 kWh</td>
<td>2000sq ft/5000sq ft x 100 kWh = 40 kWh</td>
</tr>
<tr>
<td><strong>Operation Hours</strong></td>
<td>1 hr.</td>
<td>1 hr.</td>
</tr>
<tr>
<td><strong>Allocated kWh based on operation hours</strong></td>
<td>4-ton for 1 hour = 40% = 40 kWh</td>
<td>4-ton for 1 hour = 40% = 40 kWh</td>
</tr>
</tbody>
</table>
2. *The deviation from setpoint:*
   A unit with space temperature of 78°F and setpoint turned down to 72°F will be more loaded than the same sized unit with a setpoint of 75°F and a nearly satisfied space at 75.5°F.

3. *Thermo step (the expansion valve position):*
   This gives an approximation of how much loading a unit is going to have. As the system nears target temperature, the indoor unit will modulate its expansion valve more closed than when it is fully loaded.

Indoor unit heat load (depending on the operation condition) = Power consumption of indoor unit fan (if measured) + Power consumption of optional heater

+ (The rated power consumption in cooling*1 x a )
+ (The rated power consumption in heating*1 x b )

\[
a = (a_1 + a_2) \times T \times \text{(Thermo-step)}^{*2}
\]

\[
b = (b_1 + b_2) \times T \times \text{(Thermo-step)}^{*2}
\]

a1, a2: correction factor for cooling
b1, b2: correction factor for heating
T: indoor unit’s suction air temperature
*1: The value which is registered at the test run, adapting the indoor unit’s capacity.
*2: Thermo-step “signifies that an air conditioning capacity is expressed in a range of the values 0-5 mainly based on the opening grade of an electronic expansion valve in an indoor unit.

Ex: Tenant A energy consumption (kWh) = \[
\frac{Y(kWh) \times \text{The heat load for one hour (X_a)}}{\text{Total heat load for one hour (X_a + X_b + X_c + X_d + X_e + X_f)}}
\]

Y: The energy consumption by the outdoor units
6.2 Logic 2: Partial Off

When the outdoor unit stops, it still consumes some power “Standby Power”. (e.g. compress crankcase heater, PC board). The tenants share the standby power with a fixed value based on tenant’s indoor unit size.

Ex: Tenant A partial off (kWh) = \[\frac{Z \text{ (kWh) } \times 2 \text{ (Tons)}}{(2+3+5) \text{ (Tons)}}\]

\[Z\]: The rated energy consumption for crank case heater and outdoor unit PCB.
6.3 Logic 3: All Off

When all outdoor units have stopped during the calculation period, the power consumption measured by the power meter is divided by coefficient of each indoor unit model size.

Ex: Tenant A (kWh) = \( \frac{Y \text{ (kWh)} \times 2 \text{ (Tons)}}{(2+3+5+2+2+6) \text{ (Tons)}} \)

\( Y \): The energy consumption by the outdoor units

An overall diagram of the PPD calculation is as following:
7. Accessing PPD Data Results

The HVAC system administrator should be aware that they will get relatively raw data output as a result of the PPD data retrieval. This means a series of Excel .csv (comma separated values) files indicating individual indoor units and their respective watt-hour power consumption data over various blocks of time. Organization, formatting, compilation and presentation of this data in an end-user billable format is the sole responsibility of the building owner.

7.1 Accessing PPD Results Data from the intelligent Touch Controller™

The PPD results data (Microsoft Excel .csv files) can be accessed directly through a download to a user supplied PCMCIA memory card slot or can be accessed through the web option available for the intelligent Touch Controller (accessing the web option requires an additional license key). The web option is highly recommended due to the efficiency and convenience of this method as well as the ability to retrieve the data from offsite locations.
### Example Screenshot of Microsoft Excel® .csv PPD Data Output – 5 Day Date Range

<table>
<thead>
<tr>
<th>Indoor unit Name</th>
<th>Horsepower of indoor unit</th>
<th>Amount of power used in Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECEPT A</td>
<td>70</td>
<td>79676</td>
</tr>
<tr>
<td>RECEPT B</td>
<td>70</td>
<td>43051</td>
</tr>
<tr>
<td>RECEPT C</td>
<td>70</td>
<td>59034</td>
</tr>
<tr>
<td>102</td>
<td>70</td>
<td>31487</td>
</tr>
<tr>
<td>103</td>
<td>70</td>
<td>84200</td>
</tr>
<tr>
<td>104</td>
<td>70</td>
<td>35606</td>
</tr>
<tr>
<td>105</td>
<td>70</td>
<td>81052</td>
</tr>
<tr>
<td>106a</td>
<td>70</td>
<td>99384</td>
</tr>
<tr>
<td>106d</td>
<td>70</td>
<td>7667</td>
</tr>
<tr>
<td>CONFERENCE</td>
<td>8c</td>
<td>69307</td>
</tr>
<tr>
<td>OFFICE D</td>
<td>70</td>
<td>53727</td>
</tr>
<tr>
<td>ROOM 115</td>
<td>38</td>
<td>43486</td>
</tr>
<tr>
<td>OFFICE A</td>
<td>70</td>
<td>23757</td>
</tr>
<tr>
<td>OFFICE B</td>
<td>70</td>
<td>46159</td>
</tr>
<tr>
<td>OFFICE C</td>
<td>70</td>
<td>63086</td>
</tr>
<tr>
<td>COPY</td>
<td>38</td>
<td>1687</td>
</tr>
<tr>
<td>MEETING</td>
<td>38</td>
<td>188103</td>
</tr>
<tr>
<td>113 &amp; 114</td>
<td>38</td>
<td>49046</td>
</tr>
<tr>
<td>VERNE</td>
<td>70</td>
<td>99621</td>
</tr>
<tr>
<td>COMMERCIAL A</td>
<td>70</td>
<td>31339</td>
</tr>
<tr>
<td>COMMERCIAL B</td>
<td>70</td>
<td>150663</td>
</tr>
<tr>
<td>BREAK CA</td>
<td>8c</td>
<td>119284</td>
</tr>
<tr>
<td>BREAK TR</td>
<td>8c</td>
<td>84077</td>
</tr>
<tr>
<td>TRAIN A</td>
<td>70</td>
<td>49804</td>
</tr>
<tr>
<td>TRAIN B</td>
<td>38</td>
<td>151258</td>
</tr>
<tr>
<td>TRAIN C</td>
<td>70</td>
<td>27600</td>
</tr>
<tr>
<td>LIVING</td>
<td>47</td>
<td>19405</td>
</tr>
<tr>
<td>KITCHEN</td>
<td>38</td>
<td>25702</td>
</tr>
<tr>
<td>BED</td>
<td>24</td>
<td>819</td>
</tr>
</tbody>
</table>

- **Start date for the report**
- **Number of days in the report**
- **Indoor unit Number**
- **Indoor unit Name**
- **Horsepower of indoor unit**
- **Amount of power used in Watt**
7.2 Accessing PPD Results Data from the intelligent Touch Manager™

The PPD results data (Microsoft Excel .csv files) can be accessed directly through downloading the PPD file to a user supplied USB drive or can be accessed through the web option of the intelligent Touch Manager. The web option is highly recommended due to the efficiency and convenience of this method as well as the ability to retrieve the data from an offsite location.

Example Screenshot of PPD Data Access on the intelligent Touch Manager™
8. Summary

The PPD function in combination with an iTC or iTM provides a way to proportionally calculate and display the electricity amount used by the VRV system per tenant.

The input to the PPD function includes measured pulses in the refrigerant system and because the air-conditioning system includes a number of variables, operating temperatures and pressures, piping length, heat exchange rates and others, no meter-type apportionment of individual users’ consumption can be made. However, the PPD function provides an apportionment methodology that uses highly advanced technology as applied to the many variables in the VRV system.
WARNING

• Only qualified personnel must complete installation.

• Consult your Daikin dealer regarding relocation and reinstallation of the remote controller. Improper installation may result in electric shock or fire.

• Electrical work must be performed in accordance with relevant local and national regulations, and with the instructions in this installation manual. Improper installation may cause electric shock or fire.

• Only use specified accessories and parts for installation. Failure to use specified parts may result in electric shock, fire, or controller damage.

• Do not disassemble, reconstruct, or repair. Electric shock or fire may occur.

• Only use specified wiring and verify all wiring is secured. Assure no external forces act on the terminal connections or wires. Improper connections or installation may result in electric shock or fire.

• Confirm power to the unit is OFF before touching electrical components.