API Instructions (RESTful) Version 2

May 5, 2022

I. Contents

II. Introduction

The Denowatts service includes API access to two call types:

1. Raw Deno simulator records (1-minute daytime) for diagnostics use cases; or
2. Site Performance records (15-minute) for performance management use cases

The resource URL is the same for both forms, while the channel ID determines the form of the record to be generated. Channel IDs can be obtained on https://my.denowatts.com:

Call Type	**Record Interval (minutes)**	**Channel ID Location**
Raw Deno (ending timestamp)	1m daytime 5m twilight 15m night	Deno Group Management
Site Performance (beginning timestamp)	15m	Site Info

Monitoring services, customer enterprise applications, and other performance-related uses should use the Site Performance records for "Next Day Processed" and "Deno Clean Data".

Real-time services such as aerial inspections, commissioning, and monitoring validation may choose to use Raw Deno records for low latency data.

Call Type	**Data**	**Availability**	**Use Case**
Raw Deno	Irradiance Cell Temperature Expected Power	~2 Minutes	Aerial Inspections Onsite Commissioning Monitoring Setup and Data Validation
Site Performance	*"Unprocessed Performance"* Deno Weather Remote Weather Measured Generation Expected Energy	1 Hour	Monitoring Services Customer Enterprise Applications
	"Next Day Processed" Key Performance Indices (KPIs) Learned Energy Losses (unvalidated)	Next Day	
	"Deno Clean Data" Losses (Validated)	5-Day	

III. GET Request Limitations

The Maximum Time Range per call is 7 days for Raw Deno records and 60 days for Site Performance records. Raw records are only accessible for 30 days after the timestamp.
Each Denowatts Account is allowed 30 calls per minute for both API calls.
No concurrent requests are allowed.

Error 400 is returned if requests exceed these limitations

IV. Raw Deno Records

Use Case: The user would like to obtain raw weather and energy simulation data records from all Deno sensors at a Site. A 2-minute record latency is acceptable.

The raw records deliver all timestamped records from individual Deno sensors. This method allows for direct weather and energy simulation readings to be obtained from a single Deno. The Raw Channel ID is set by a Deno order during the initial site setup, so the API call will remain unchanged during any physical replacement of Deno Simulators.

Raw Deno record GET requests should be delayed at least 2-minutes after the desired record timestamp during daytime (>100 w/m^2). For example, the GET request for the 8:00 record should be requested at 8:02. Raw Deno records use an ENDING timestamp convention, meaning a record with timestamp 8:00 will include data sampled from 7:59 through 8:00.

Resource URL

https://api.denowatts.com/api/v2/raw_data/

Parameters

Parameter	Description	Example values
channel_id	Site, array and asset specific channel_id. Get array specific channel ID from array information section of the portal and asset specific channel ID from attached assets section.	243fed850943kh35c3mjac4e8cc44f94
start_date	ISO 8601-formatted datetime for the start of the requested time span, in the timezone of the installed energy system	2013-09-25T00:00:00 (Seconds won't matter) or Simply 2013-09-25
end_date	ISO 8601-formatted datetime for the end of the requested time span, in the timezone of the installed energy system	2013-09-26T00:00:00 (Seconds won't matter) or Simply 2013-09-26
page	Page number of the requests, starting from 1 by default.	2
Order	"reverse" changes the newest timestamps to appear at the top of the response	reverse

Response Values

Value	Description	Example values
status	Status of the request made	"OK" for good result, "ERROR" for any kind of error, see msg node for details
msg	When any error occurs, both from api or from user input parameter, this node will contain the error message	End date has to be greater than Start date
total_records	Total records found in a given range	498
data	List of key/val pairs indicating the node identifier and value for each node included in the request. (one record for each 15-min interval)	Array
data[i].timestamp	Timestamp of each record in system's timezone	2022-05-01 11:45:00
data[i].timestamp_iso	Timestamp of each record in system's timezone in ISO format	2022-05-01T11:45:00-04:00
Data[i].irr_front_val	Front side plane of array effective irradiation (fPOA) value of the interval (w/m^2)	653.2
Data[i].irr_aux_val	Auxiliary pyranometer irradiance value (may be GHI or rPOA)	112.4
data[i].tcell	Cell temperature (C)	38.66
data[i].tbom	Back of module temperature (C)	36.72
data[i].rssi	Radio Signal Strength (-dBi)	42
data[i].lag	Data record latency, Deno to Server (s)	8
data[i].vcap	Deno charge voltage (3.4V to 5.2V)	5.18

Example GET Request

Raw Deno Data

https://api.denowatts.com/api/v2/raw_data?start_date=2022-05-1&end_date=2022-05-2&channel_id=example

```
"status": "OK",
    "total_records": 74,
    "data": [
        {
            "timestamp": "2022-05-05 06:00:45",
            "timestamp_iso": "2022-05-05T06:00:45-05:00",
            "irr_front_val": 4.0894,
            "irr_aux": 0.2,
            "expected_val": 8.7891,
            "tcell": -1.4,
            "tbom": -1.4,
             "rssi": -42,
             "lag": 8,
             "vcap": 5.18
        },
```


V. Site Performance Records

Use Case: The user would like to obtain 15-minute weather, including remotely reported ambient temperature, wind speed/direction, precipitation, measured generation, and performance diagnostics. The 15-minute records include an average of all Deno sensors that are attached to an Array. A 60-minute delay in record availability (unprocessed), Next Day availability (processed), or 5-Day availability ("Deno Clean") is acceptable.

The Site Performance records return aggregated data from all Deno sensors attached to a Site. Sites are configured in the Customer Portal and are analogous to individual energy models. A Site may have one or more Deno sensors attached to provide weather and energy simulation data. Local ambient weather conditions are also included in this API based on the site's geographical coordinates (provided by IBM Enhanced Local Conditions). The Site Performance Channel ID is generated when each Site is created, so the API call will remain unchanged during any replacement of Deno sensors.

The availability of record information depends on the use case. For example, performance technicians may obtain basic performance metrics such as Energy Performance Index (EPI) within 75 of the record timestamp (unprocessed) which may be helpful for same-day performance analysis. O&M services and customer dispatch may choose to obtain Site Performance data the following day (after 6:00 am EST) to see Learned Energy and Losses waterfall (unvalidated). Finally, analysts providing monthly performance reports may choose to call each month of data on the 5th day of the following month to obtain validated losses data (termed "Deno Clean Data" by our marketing department).

Resource URL

https://api.denowatts.com/api/v2/data/

Parameters

Parameter	Description	Example values
channel_id	Site, array and asset specific channel_id. Get array specific channel ID from array information section of the	243fed850943kh35c3mjac4e8cc44f94

	portal and asset specific channel ID from attached assets section.	
start_date	ISO 8601-formatted datetime for the start of the requested time span, in the timezone of the installed energy system	2013-09-25T00:00:00 (Seconds won't matter) or Simply 2013-09-25
end_date	ISO 8601-formatted datetime for the end of the requested time span, in the timezone of the installed energy system	2013-09-26T00:00:00 (Seconds won't matter) or Simply 2013-09-26
page	Page number of the requests, starting from 1 by default.	2
Order	"reverse" changes the newest timestamps to appear at the top of the response	reverse

Response Values

Value	**Description**	**Example values**
status	Status of the request made	"OK" for good result, "ERROR" for any kind of error, see msg node for details
msg	When any error occurs, both from api or from user input parameter, this node will contain the error message	End date has to be greater than Start date
total_records	Total records found in a given range	498
kpi_data	Key performance indices for the selected times. List of key/val pairs indicating the node identifier and value for each node included in the request.	99.3
kpi_data.measured_energy_total	Total cumulative measured site generation for the selected time period (kWh)	13303
kpi_data.expected_energy_total	Total cumulative expected energy for the selected time period (kWh)	13059
kpi_data.learned_energy_total	Total cumulative learned energy for the selected time period (kWh)	14724
kpi_data.commissioned_energy_total	Total cumulative commissioned energy for the selected time period (kWh)	13195
kpi_data.EPI	Expected Performance Index	92.29
kpi_data.LPI	Learned Performance Index	90.93
kpi_data.CPI	Commissioned Performance Index	100.82

data	List of key/val pairs indicating the node identifier and value for each node included in the request. (one record for each 15-min interval)	Array
data[i].timestamp	Timestamp of each record in system's timezone	2022-05-01 11:45:00
data[i].timestamp_iso	Timestamp of each record in system's timezone in ISO format	2022-05-01T11:45:00-04:00
data[i].timestamp_utc	Timestamp of each record in UTC	2022-05-01 15:45:00
data[i].sunrise_time_local	Sunrise Time Local	2022-05-01 05:40:02
data[i].sunset_time_local	Sunset Time Local	2022-05-01 19:54:11
data[i].irr_eff_cumul	Cumulative total effective irradiation (fPOA + rPOA*rearside_factor) value (kWh/m^2)	68.7371
data[i].irr_eff_val	Total effective irradiation (fPOA + rPOA*rearside_factor) value of the interval (w/m^2)	976.634
data[i].irr_front_cumul	Cumulative front side plane of array effective irradiation (fPOA) value of the interval (kWh/m^2)	66.8454
data[i].irr_front_val	Front side plane of array effective irradiation (fPOA) value of the interval (w/m^2)	952.944
data[i].irr_rear_cumul	Cumulative rear plane of array irradiation (rPOA) value of the interval (kWh/m^2)	0.1735
data[i].irr_rear_val	Rear side plane of array irradiation (rPOA) value of the interval (w/m^2)	40.646
data[i].irr_ghi_cumul	Cumulative global horizontal irradiation (GHI) value of the interval (kWh/m^2)	0
data[i].irr_ghi_val	Global horizontal irradiation (GHI) value of the interval (w/m^2)	0
data[i].tcell	Cell temperature (C)	38.66
data[i].tbom	Back of module temperature (C)	36.72
data[i].tamb	Ambient temperature (C) (via The Weather Company)	14.5
data[i].wind_speed	Wind Speed (km/hr) (via The Weather Company)	12.5

data[i].wind_direction	Wind Direction (Deg) (via The Weather Company)	350
data[i].snow_24hour	Cumulative Snow (cm in last 24 hour) (via The Weather Company)	0.23
data[i].snow_15min	Cumulative Snow (cm in last 15 mins) (via The Weather Company)	0.08
data[i].precip_24hour	Cumulative Precipitation (mm in last 24 hour) (via The Weather Company)	8.57
data[i].precip_15min	Cumulative Precipitation (mm in last 15 mins) (via The Weather Company)	0.19
data[i].expected_cumul	Expected Energy value (MWh)	888.3556
data[i].expected_val	Expected Power value of the interval (kW)	1631.85
data[i].comp_cumul	Cumulative comparative energy value (MWh)	888.0338
data[i].comp_val	Comparative power value of the interval (kW)	1632.802
data[i].learned_val	Learned power value of the interval (kW)	1607.62
data[i].measured_cumul	Cumulative measured site generation energy value (MWh)	699.6593
data[i].measured_val	Measured site generation power value of the interval (kW)	1493.2
data[i].systemic_loss	Site generation lost to systemic issues (kW)	0
data[i].shade_loss	Site generation lost to shade (kW)	0
data[i].snow_loss	Site generation lost to snow (kW)	0
data[i].outage_loss	Site Generation lost to outages (kW)	114.42
next_page	States if there is any next page of records of current request. Usually we provide max 2000 records at one request.	true

Example GET Requests

Site Performance

https://api.denowatts.com/api/v2/data?start_date=2022-05-1&end_date=2022-05-2&channel_id=example


```
{
    "status": "OK",
    "total_records": 97,
    "kpi_data": {
        "measured_energy_total": 13303,
        "expected_energy_total": 13059,
        "learned_energy_total": 14724,
        "commissioned_energy_total": 13195,
        "EPI": 92.29,
        "LPI": 90.93,
        "CPI": 100.82
    },
    "data": [
        {
            "timestamp": "2022-05-01 09:45:00",
            "timestamp_iso": "2022-05-01T09:45:00-04:00",
            "timestamp_utc": "2022-05-01 13:45:00",
            "sunrise_time_local": "2022-05-01 05:40:02",
            "sunset_time_local": "2022-05-01 19:54:11",
            "irr_eff_cumul": 67.0347,
            "irr_eff_val": 648.3,
            "irr_front_cumul": 65.1869,
            "irr_front_val": 628.914,
            "irr_rear_cumul": 0.0981,
            "irr_rear_val": 33.258,
            "irr_ghi_cumul": 0,
            "irr_ghi_val": 0,
            "tcell": 32.67,
            "tbom": 30.52,
            "tamb": 10.25,
            "wind_speed": 5.3,
            "wind_direction": 30,
            "snow_24hour": 0,
            "snow_15min": 0,
            "precip_24hour": 0,
            "precip_15min": 0,
            "expected_cumul": 885.1302,
            "expected_val": 1396.362,
            "comp_cumul": 884.8155,
            "comp_val": 1381.034,
            "learned_val": 1494.2549,
            "measured_cumul": 696.7258,
            "measured_val": 1351.6,
            "systemic_loss": 0,
            "shade_loss": 0,
            "snow_loss": 0,
            "outage_loss": 142.6549
        },
        {
            "timestamp": "2022-05-01 10:00:00",
```

```
        "timestamp_iso": "2022-05-01T10:00:00-04:00",
        "timestamp_utc": "2022-05-01 14:00:00",
        "sunrise_time_local": "2022-05-01 05:40:02",
        "sunset_time_local": "2022-05-01 19:54:11",
        "irr_eff_cumul": 67.2099,
        "irr_eff_val": 701.05,
        "irr_front_cumul": 65.3572,
        "irr_front_val": 681.024,
        "irr_rear_cumul": 0.1067,
        "irr_rear_val": 34.364,
        "irr_ghi_cumul": 0,
        "irr_ghi_val": 0,
        "tcell": 31.95,
        "tbom": 28.54,
        "tamb": 11,
        "wind_speed": 6,
        "wind_direction": 0,
        "snow_24hour": 0,
        "snow_15min": 0,
        "precip_24hour": 0,
        "precip_15min": 0,
        "expected_cumul": 885.5082,
        "expected_val": 1512.89,
        "comp_cumul": 885.1895,
        "comp_val": 1495.962,
        "learned_val": 1607.62,
        "measured_cumul": 697.0637,
        "measured_val": 1434,
        "systemic_loss": 0,
        "shade_loss": 0,
        "snow_loss": 0,
        "outage_loss": 173.62
    },
    {
        "timestamp": "2022-05-01 10:15:00",
        "timestamp_iso": "2022-05-01T10:15:00-04:00",
        "timestamp_utc": "2022-05-01 14:15:00",
        "sunrise_time_local": "2022-05-01 05:40:02",
        "sunset_time_local": "2022-05-01 19:54:11",
        "irr_eff_cumul": 67.3974,
        "irr_eff_val": 749.9,
        "irr_front_cumul": 65.5395,
        "irr_front_val": 729.256,
        "irr_rear_cumul": 0.1155,
        "irr_rear_val": 35.418,
        "irr_ghi_cumul": 0,
        "irr_ghi_val": 0,
        "tcell": 31.04,
        "tbom": 27.15,
        "tamb": 11.5,
        "wind_speed": 8,
        "wind_direction": 0,
        "snow_24hour": 0,
        "snow_15min": 0,
        "precip_24hour": 0,
        "precip_15min": 0,
        "expected_cumul": 885.9081,
```

```
            "expected_val": 1599.066,
            "comp_cumul": 885.5871,
            "comp_val": 1590.244,
            "learned_val": 1607.62,
            "measured_cumul": 697.4222,
            "measured_val": 1482.4,
            "systemic_loss": 0,
            "shade_loss": 0,
            "snow_loss": 0,
            "outage_loss": 125.22
        }
    ],
    "next_page": false
}
```