Distributed Energy Resources (DER) Connections Review

Technical Sub-Group

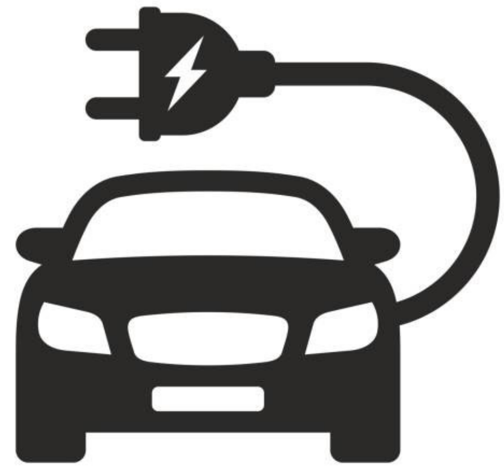
Bi-directional Chargers (e.g EV, BESS etc.)

April 27, 2022

Overview

- EV Paradigm Shift
  - Existing EV's (unidirectional)
  - Bi-direction EV's
  - Stationary vs. Moving Batteries comparison (e.g. EV)

- Connection Considerations
  - Net Metered, BESS, and now EV
  - Load vs. Generation Balance
  - Thermal/Short Circuit
  - Monitoring / Control

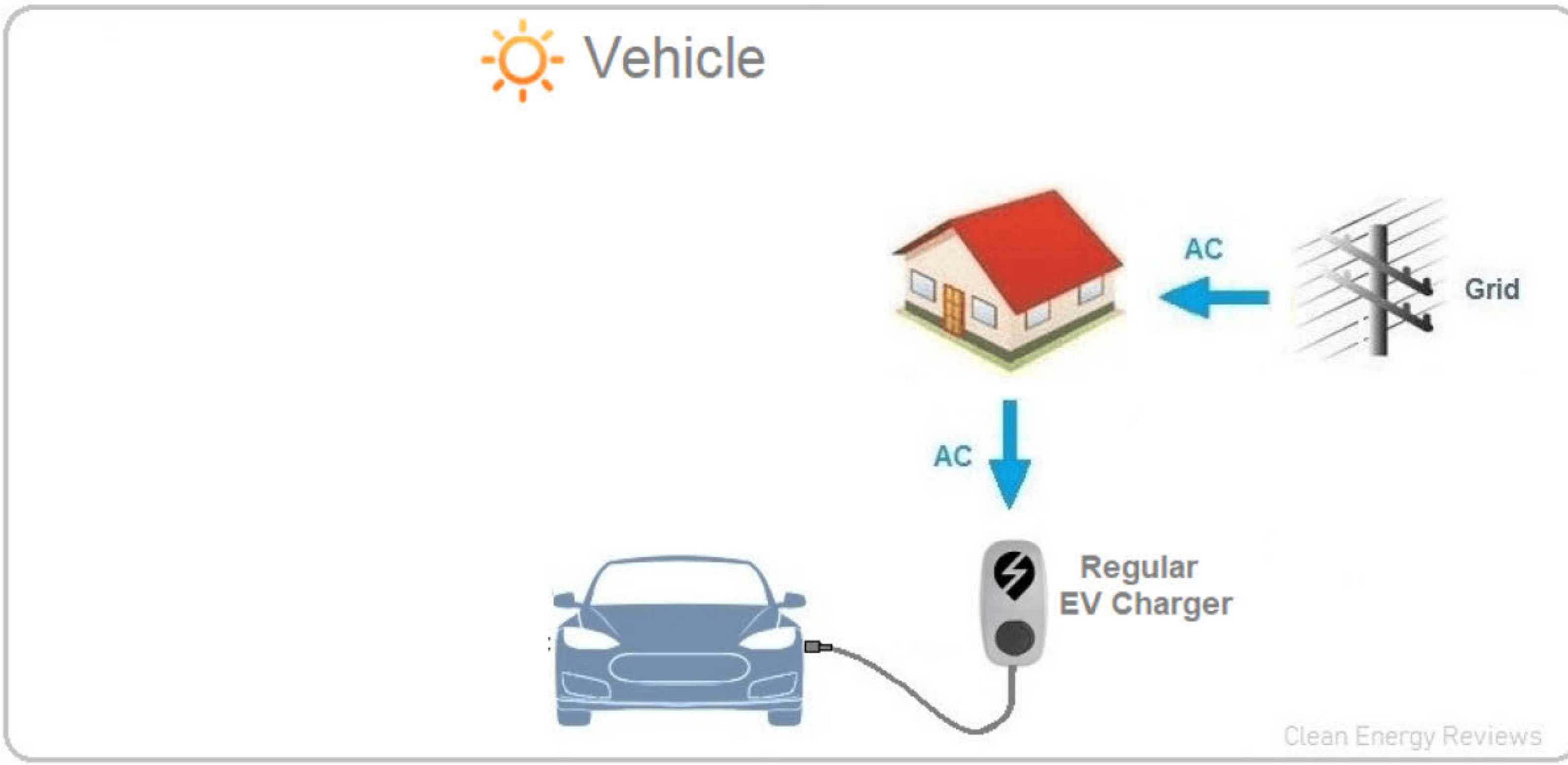


EVs - Why does this matter…

- Shift from unidirectional (e.g. Load) to bi-directional (load or source) will require more nuanced connection applications.
- Integration of bi-direction EV’s with existing DER (e.g. Solar, Wind) at the single phase level creates unique challenges/opportunities.
- EV’s with onboard inverters can create a unique connection issue.
- Wide scale uptake of EV’s and specifically bi-directional EV’s will grow in the coming years and connection process needs to be robust enough to deal with that.

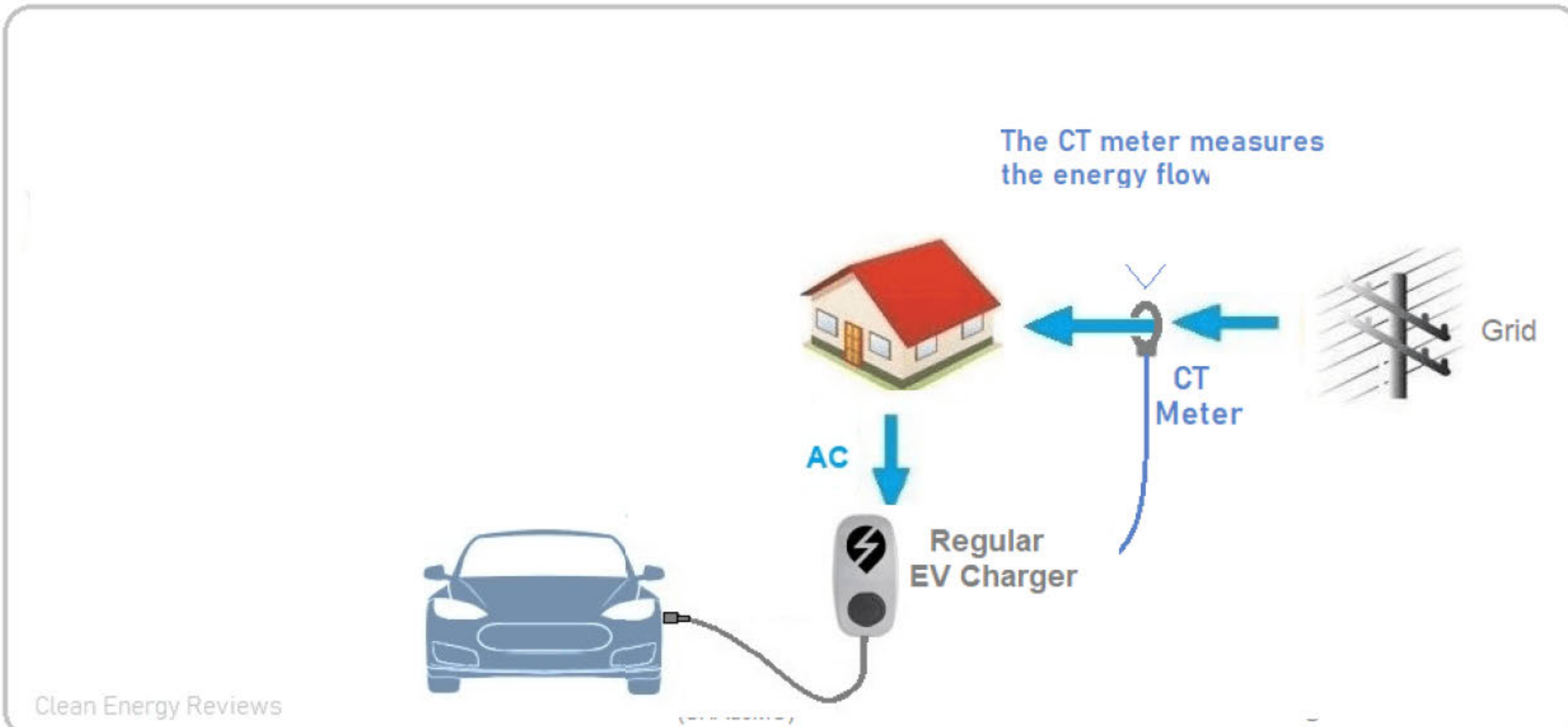
EV Charging

- EV Charger – unidirectional power flow – no export.
- Control – no specific control/curtailment in this example



EV Charging + Control

- EV Charger – can pull from the grid and amount is varied/controlled
- Control – limits consumption to not overload building distribution system.



Conventional EV Chargers

Charging Level	Type	Current	Voltage	kW	Connector	Applications
LEVEL 1	AC	~8 to 12A	120 VAC	1 to 1.5 kW	J1772, Tesla	PHEV
LEVEL 2	AC	20 to 40A (but can be up to 80A)	208/240 VAC	7 to 20 kW	J1772, Tesla	PHEV / BEV
LEVEL 3	DC	100 to 125A (Varies)	400V – 900 VDC	40 kW to 100 kW+	CHAdeMO / Combo (CCS)	BEV

- The LEVEL 3 can include some storage component (e.g. buffering) or can be direct (e.g. 3 phase direct connection).

Charging Connectors - Example

Current type	Region			
	Japan	America	Europe, rest of world	China
AC				
Plug name:	J1772 (or Type 1)	J1772 (or Type 1)	Mennekes (or Type 2)	GB/T
DC				
Plug name:	CHAdeMO	CCS1	CCS2	GB/T

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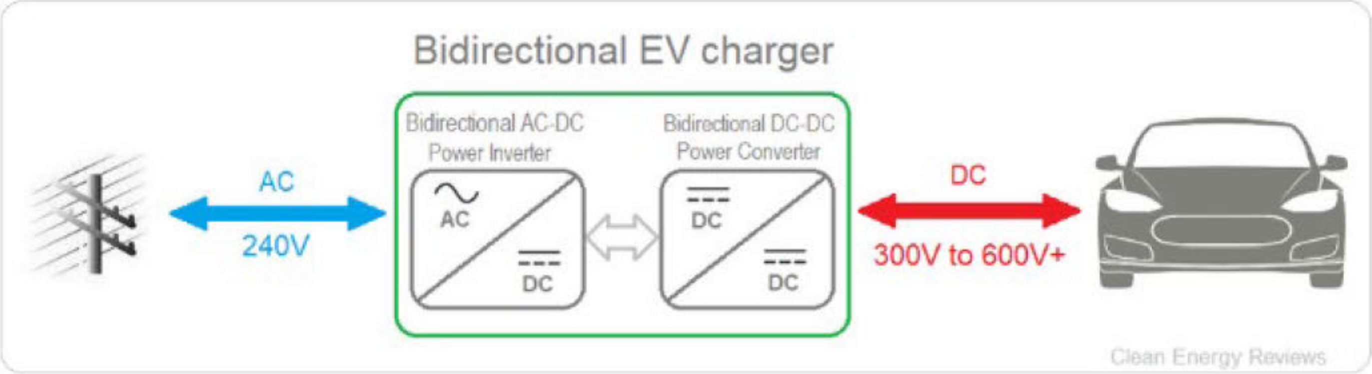
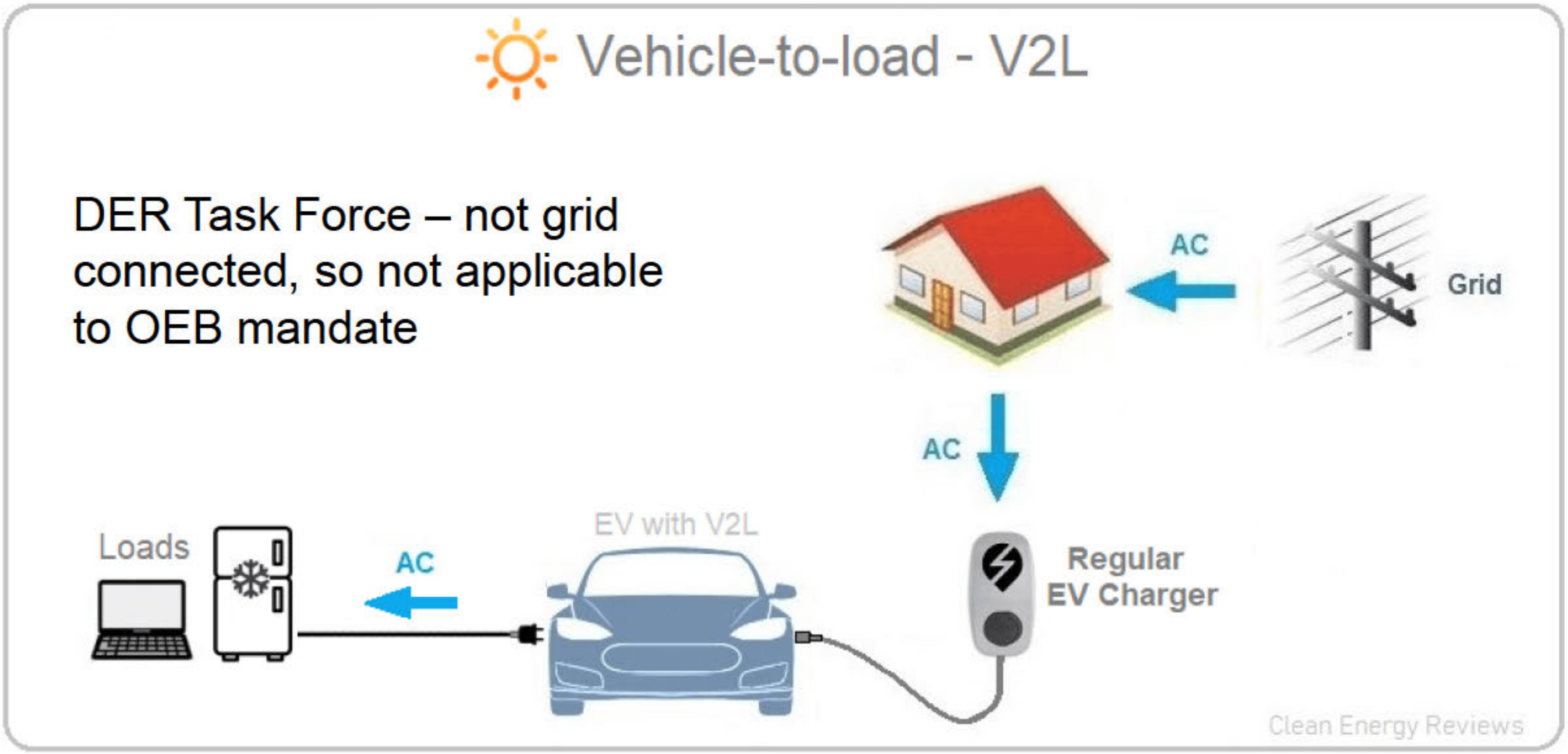
EV Paradigm Shift – Bi-directional Charging



Modes	V2L	V2H	V2B	V2G
System Powered	Load	Home	Building	Grid
Synchronous Operation	No	Either	Either	Yes
Charger /Inverter	Mobile	Stationary / Mobile	Stationary / Mobile	Stationary (currently)
Fault Current Contributor	No	Possibly	Possibly	Yes
Export Control	No	Yes	Yes	No

V2L – Base Case

- EV Charger – can pull from the grid or <u>vehicle</u> can power loads
- Load – is supplied from non-synchronous on-board inverter



DER Task Force – not grid connected, so not applicable to OEB mandate

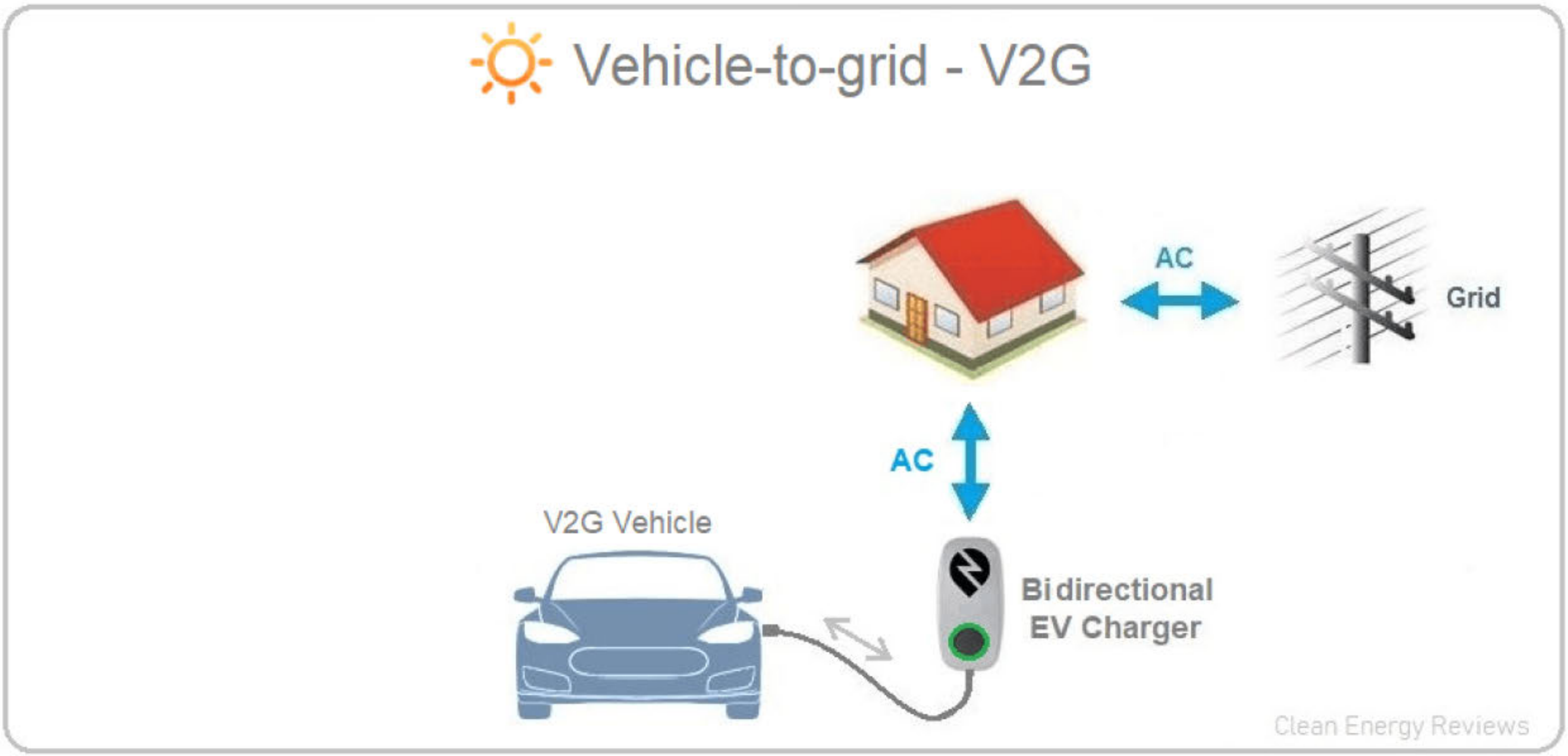
V2L – Standard Options Available

- Mitsubishi Outlander PHEV
  - 1 outlet x 1.5 kW = 1.5 kW
- Hyundai IONIQ5 / Kia EV6
  - 1 outlet x 3.6 kW = 3.6 kW
- Ford F150
  - 4 outlets x 2.4 kW = 9.6 kW

At present all of these are considered islanded loads and so would be treated like a standalone back-up generator and non-synchronous.

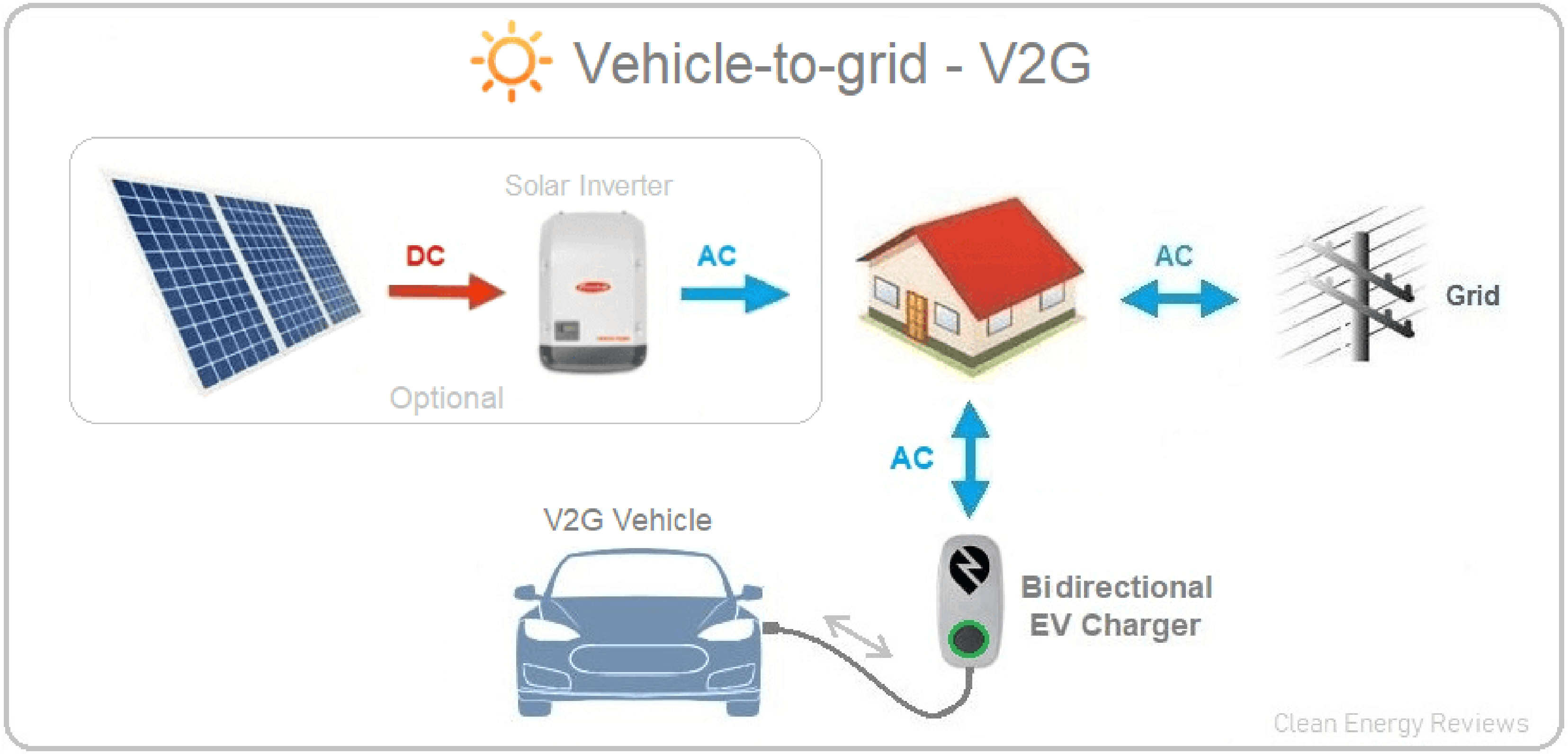
V2G (Grid) – Base Case

- EV Charger – can pull from the grid or export to the grid.
- Control – no specific control/curtailment required in this application



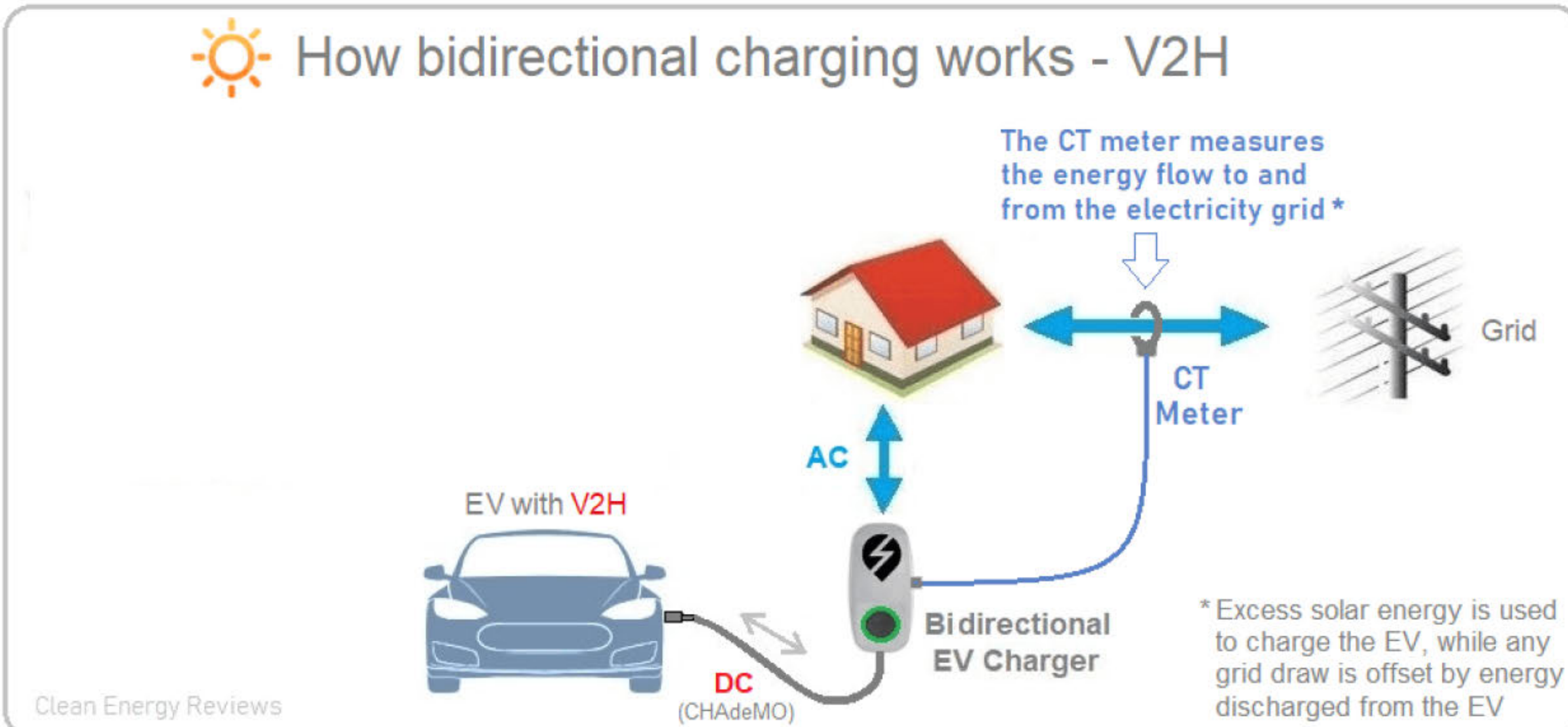
V2G (Grid) – Base Case + Solar

- EV Charger – can pull from the grid or export to loads/grid
- Net Metering – of solar and storage export is permitted
- Control – no specific control/curtailment in this application



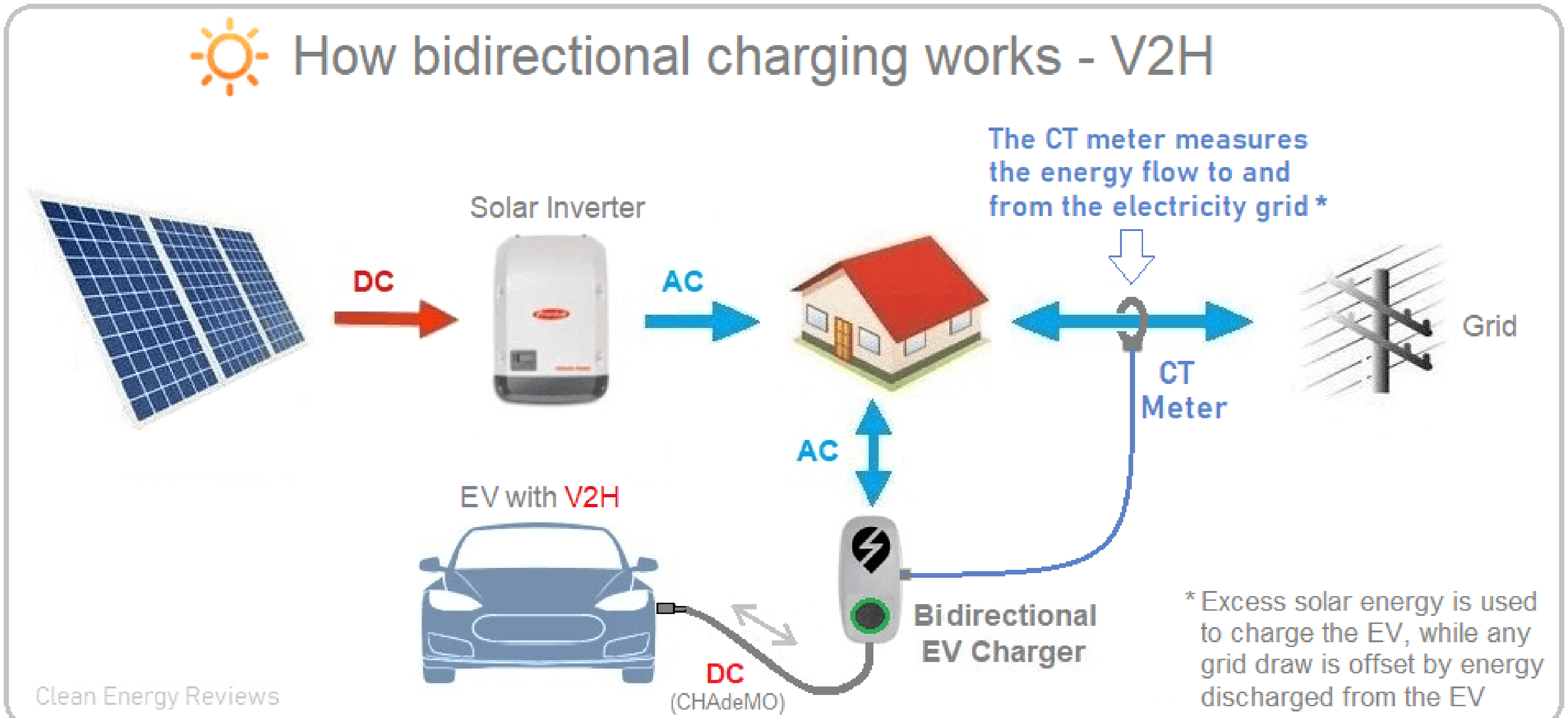
V2(H/B/G) – Export Control

- EV Charger – can pull from the grid or export to loads
- Net Metering – not permitted as there is no renewable energy
- Control – limits generation to onsite loads (e.g CT is >=0)



V2(H/B/G) – Export Control + Solar

- EV Charger – can pull from the grid or export to loads/grid
- Net Metering – permitted, so export control limited (e.g. to say 10 kW)
- Control – curtails inverter/EV output to meet export limits



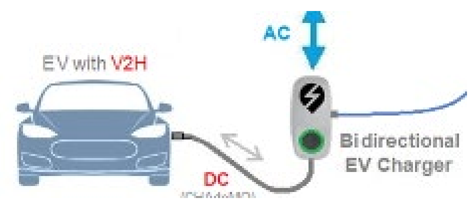
What is the technical challenge?

- Multiple DER sources at the residential scale can drive up the cost and complexity of connections:

- Net Metered Solar
  - 5 to 10 kW (historically)
  - Increasingly 20 to 30 kW

- Battery ES System
  - 5kW to 10 kW per unit
  - Multiple units is more common

- EV Bi-Directional Charger
  - 7.6 kW to 11 kW+ per unit (plus)
  - Likely integration with other systems



Why is this a concern?

- Electrical Safety Authority – is reviewing inspections, and no mandated link with LDC for projects not requiring with ESA Plan Review (for example anything less than):
    - a three-phase consumer service or standby generation, equal to or over 400 amp circuit capacity
    - a single-phase consumer service or standby generation equal to or over 600 amp
    - consumer-owned electric power generating equipment or energy storage systems, with a rating in excess of 10 kW (Micro Size) as defined by the Ontario Energy Board, and operating in parallel with a supply authority system

- In some cases, the projects may be non-exporting, and individual units do not exceed 10 kW, or are deployed incrementally and ESA Plan Review is not required so no link to LDC process.

What is the application challenge?

- CIA Application Costs (and more importantly the resulting Connection Costs) – can be cost prohibitive for projects in the >10kW to 30 kW range
- Multiple DER sources at the residential / small commercial scale can drive up the cost and complexity of connections specifically with incremental expansion.
- Form B does not specifically address the EV Bi-Directional Chargers.
- Existing Form C (micro threshold) – typically residential and small commercial does not address bi-directional chargers, and in some cases isn’t being filed for conventional small scale BESS (due to misunderstanding about export).

Discussion Item 1: Increase “micro” from 10kW to a higher threshold.

Many devices including bi-directional chargers are at or over the 10 kW threshold (see Appendix below) and from a connections standpoint there is an opportunity to acknowledge, this, reduce the burden for LDC’s and applicants in terms of processing.

Q: Would it be appropriate to increase the micro-gen connection threshold to, say, 20 or 30 kW depending on type?

Grid Connection Type	Micro Threshold (e.g. Form C)	Nominal Current (at low-voltage)
Single Phase	20 kW	~83.3A @ 240 VAC 1p
Three Phase	30 kW	~83.3A @ 208 VAC 3p

The general rationale is that the 10 KW threshold has historic origins that may no longer be appropriate (e.g. for microFIT, where most rooftop solar would have been in that range regardless). There are now many use cases in the 10 to 30 KW range (e.g. homes with two electric vehicles with bi-directional chargers, solar and EV, solar and battery, etc).

Discussion Item 2: Export Gateway Monitoring / Control impact on Assessment

Where a gateway zero export controller does not prevent short circuit contribution; it can serve a role in managing load/generation balance. Q1: So, for those applications would a gateway or export control impact the assessment process?

Q2: Thermal restrictions could be overcome with an export gateway configuration how would this impact the assessment process.

Q3: for the load/generation-based analysis would the assessment be simpler/cheaper (or avoidable) if the gateway would ensure no export under normal conditions (or throttled to the micro level e.g.,10 KW)?

Q4: Would commitments to install certain gateway or inverter settings allow for a simpler/cheaper assessment?

Discussion Item 3: Streamlined CIA for "Small" systems

The CIA and Connection Costs associated with small scale systems (e.g. in the 30 kW to 50 kW range) can be cost prohibitive for a project. Where dispatchable DER technologies are deployed (e.g. solar + EV / storage etc.)

Q1 - Can CIA / Connection costs be lowered or reduced for mid-range applications between, say, 20/30 KW to 50 KW? If yes, what would the criteria be?

- For example, would the assessment be simpler/cheaper (or avoidable) if the gateway would ensure no export under normal conditions (or throttled to micro level for output kW)?
- Would commitments to install certain gateway or inverter settings allow for a simpler/cheaper assessment (or no assessment)

APPENDIX A – Example Equipment

- Bi-Directional Chargers
- Solar Hybrid Chargers
- BESS System Sizes

Examples – Quasar 2 (by Wallbox)

Technical Details

ELECTRICAL SPECIFICATIONS

Charger:	DC
Rated power:	11.5 KW (48 A)
Connector Type:	CCS
Target Efficiency:	97%

GENERAL SPECIFICATIONS

DIMENSIONS

USER INTERFACE & COMMUNICATION

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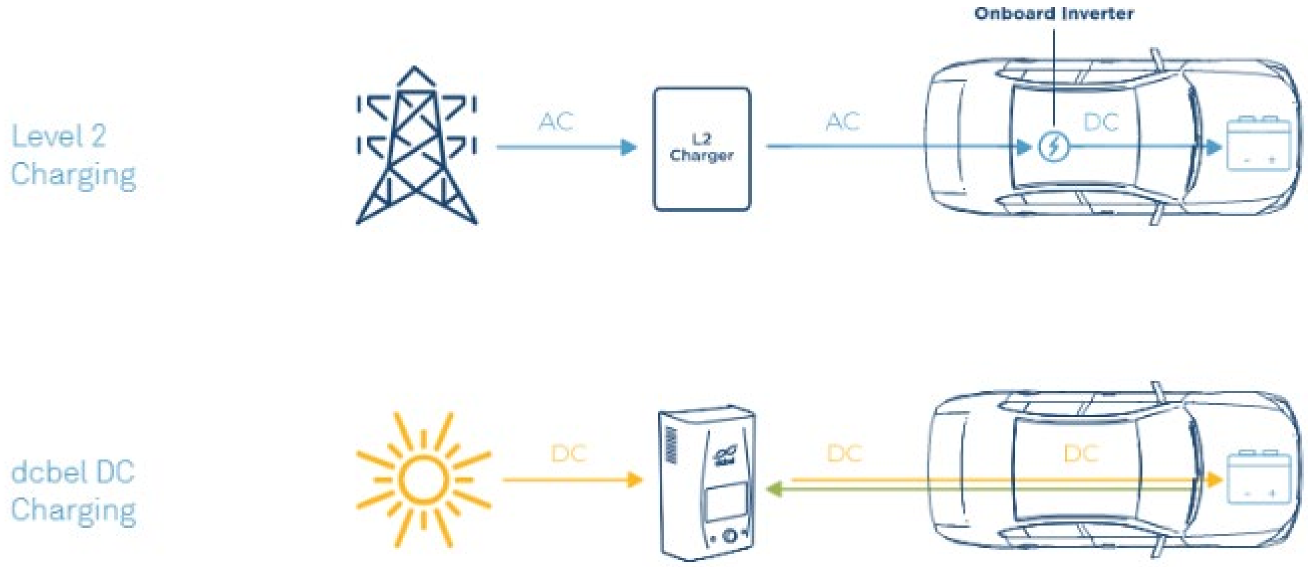
- This is paired with Nissan Leaf (after market)
- There are other integrated platforms being developed by major automakers:
  - Hyundai (on-board)
  - Volkswagen (stationary)

Example: Solar Edge Hybrid Charger

Two Power Sources → Faster Charging

	Level 2 Charger	Level 2 Charger + Solar Boost
Charge rate[1] (miles/hour)	25	30
Max Charge[2] (power)	7.7kW (32A @ 240V)	24kW (40A @ 240V)

Example: DCBel Energy



Example: Tesla PowerWall

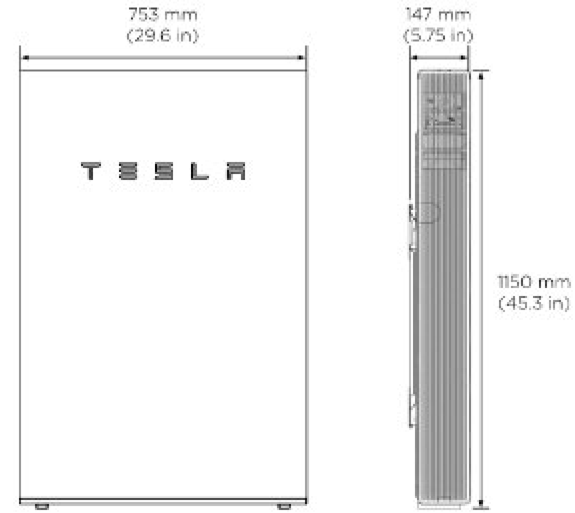
PERFORMANCE SPECIFICATIONS

AC Voltage (Nominal)	120/240 V
Feed-In Type	Split Phase
Grid Frequency	60 Hz
Total Energy	14 kWh
Usable Energy	13.5 kWh
Real Power, max continuous	5 kW (charge and discharge)
Real Power, peak (10 s, off-grid/backup)	7 kW (charge and discharge)
Apparent Power, max continuous	5.8 kVA (charge and discharge)
Apparent Power, peak (10 s, off-grid/backup)	7.2 kVA (charge and discharge)
Maximum Supply Fault Current	10 kA
Maximum Output Fault Current	32 A
Overcurrent Protection Device	30 A
Imbalance for Split-Phase Loads	100%
Power Factor Output Range	+/- 1.0 adjustable
Power Factor Range (full-rated power)	+/- 0.85
Internal Battery DC Voltage	50 V
Round Trip Efficiency[1,3]	90%
Warranty	10 years

MECHANICAL SPECIFICATIONS

Dimensions[1]	1150 mm x 755 mm x 147 mm (45.3 in x 29.6 in x 5.75 in)
Weight[1]	114 kg (251.3 lbs)
Mounting options	Floor or wall mount

[1]Dimensions and weight differ slightly if manufactured before March 2019. Contact Tesla for additional information.



ENVIRONMENTAL SPECIFICATIONS

Example: Alternatives

3. LGE ESS HOME 10 WITH 10KW LI-ION BATTERY STORAGE (LG HB 10H)

Key features:

- LFP battery storage with the RESU 10H: 9.8kWh with 10 years warranty
- Solar charger (ESS Home 10): 3 MPPT, up to 13.5kW of solar power
- DC/AC Inverter: 10kW continuous output power
- Highly efficient: 97% efficiency PV to grid
- Cost: 12'000 USD including installation, LCOS: 0.35 USD/kWh (10 years)

4. SONNEN Core – 10kWh

Key features:

- An all-in-one smart solution: combines solar charger, DC/AC smart inverter, and battery storage
- Solar charger: Up to 6kW of solar power
- Inverter: 4.8kW continuous power output
- LFP battery storage: 10 kWh with 10 years warranty.
- Cost: 12'500 USD including installation, LCOS: 0.34 USD/kWh (10 years)

- Peak Output – Ranges from 4.8 kW to 10 kW (some normalization there) – but they are stackable
- Solar Integration – some are including solar integration either directly (DC coupled) or indirectly (AC Coupled)