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Power Controls & NEC 2023

Using code to surpass the 120% rule and avoid main panel upgrades

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Power of PCS

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The status quo of home energy is changing rapidly, and with it, the importance of power control systems (PCS).

Follow the logic: The electrification of appliances and vehicles is driving up electric bills just as utilities are hiking rates. Grid reliability is also decreasing. Home solar is a great antidote, but a shift away from retail net metering to time of use (TOU) net billing means battery energy storage systems (ESS) are a necessity.

Energy management systems (EMS) ease the complexity of integrating all of these home distributed energy resources (DER). Moreover, recent updates in the National Electric Code (NEC) have positioned PCS as a central component within an EMS — and your solar + storage installation business.

"The Inflation Reduction Act (IRA) and additional local subsidies offer strong incentives for home electrification via heat pumps, induction stoves, and EV chargers," says Douglas Amarhanow, Product Manager with FranklinWH. Amarhanow has a background in electrical and mechanical engineering design and commercial construction. He has a BS in mechanical engineering, with a renewable energy focus. "These modern technologies may increase comfort in the home but also will likely drive the need for a larger utility service in the home. Upgrading the utility service for the home is an expensive and complex procedure, which earns electricians revenue but is one they do not enjoy. PCS may be used on the existing service and maintain safety in the home while each electrical appliance is used."

In this Power Controls report, we explain ...

- The definition of PCS in NEC 2020 & 2023.
- How PCS allows you to surpass the 120% rule.
- Why AC-coupled ESS is crucial for PCS.
- The role of intelligent circuits in avoiding main panel upgrades.

Chris Crowell is the Editor-in-Chief of *Solar Builder.*

Inside

NEC 2020: Power Control Systems

The introduction of a power control system (PCS) in NEC 2020 705.13 is the key to moving away from the 120% rule:

"PCS shall be listed and evaluated to control output of one or more power production sources, energy storage systems, and other equipment (ESS)."

Basically, a system can provide overcurrent protection via the PCS instead of having to rely on the breakers. Read the code below.

Amarhanow: "PCS is widely accepted at this point. It's 2024, not the 1970s. We rely on microprocessors for safety in all sorts of situations, and I am happy to see them trickling into the electrical safety space. It is no longer reasonable to wildly oversize everything in the name of safety. Plus, there is often a circuit breaker to act as a physical failsafe for the PCS."

NEC 2020 Code Language	FranklinWH Explains
705.13 A power control system (PCS) shall be listed an evaluated to control output of one or more power production sources, energy storage systems (ESS), and other equipment. The PCS shall limit current and loading on the busbars and conductors supplied by the PCS. For the circuits connected to a PCS, the PCS shall limit the current to the ampacity of the conductors or the ratings of the busbars to which it is connected in accordance with 705.13(A) through (E).	New section 705.13, Power Control Systems can allow far more than the 120% rule allows for load-side connections. Necessary for AC-coupled ESS. PCS can control the output of power production sources, ESS or other equipment.
(A) Monitoring. The PCS controller shall monitor all currents within the PCS. Any busbar or conductor on the load side of the service disconnecting means that is not monitored by the PCS shall comply with 705.12. Where the PCS is connected in accordance with 705.11, the PCS shall monitor the service conductors and prevent overload of these conductors.	PCS can limit current on conductors.
(B) Settings. The sum of all PCS controlled currents from other sources of supply shall not exceed the ampacity of any busbar or conductor supplied by the power production sources. Where the PCS is connected to an overcurrent device protecting any busbar or conductor not monitored by the PCS, the setting of the PCS controller shall be set within the ratings of the overcurrent device.	Any load side connection that is not monitored by PCS shall comply with 705.12.
(C) Overcurrent Protection. The PCS shall provide overcurrent protection either by overcurrent devices or by the PCS including the functionality as an overcurrent device in the product listing. Informational note: some PCS are listed to provide overcurrent protection.	Can provide overcurrent protection by PCS or OCPD.
(D) Single Power Source Rating. The rating of the overcurrent device for any single power source controlled by the PCS shall not exceed the rating of the busbar or the ampacity of the conductors to which it is connected.	PCS current limits not to exceed physical current capacity for conductors or other hardware.
(E) Access to Settings. The access to settings of the PCS shall be restricted to qualified personnel in accordance with the requirements of 240.6(C).	Access to PCS settings only by qualified personnel.

PCS: More Flexibility than 120% Rule

The NEC allows a few ways to interconnect PV systems to utility systems:

705.12 (B)(3)(1)
The sum of 125% of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the ampacity of the busbar.

Take the inverter output circuit and multiply it by 125%. That is the amount of current that the busbar will be subject to. Add that to the overcurrent device protecting the busbar. If those two don't exceed the busbar rating, you can put the solar output breaker wherever you want on that busbar.

705.12 (B)(3)(2)
Where two sources, one a primary power source and the other another power source, are located at opposite ends of a busbar that contains loads, the sum of the 125% of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120% of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Article 220.

This is commonly called the "120% rule." The sum of the PV AC output amps multiplied by 125%, plus the main breaker rating, cannot be greater than 120%. In many cases, after the calculation, the PV breaker is limited to a max of 40 amps with 32 amps continuous or the most famous 7.6 kW inverter output.

Installing a PCS allows you to surpass the 120% rule and connect much more to a system.

Amarhanow: "The 120% rule based on nameplate inverter output capacity is a very conservative way to comply with code requirements that leaves a lot of extra capacity on the table.

"Typically, electrical utility service is sized using NEC section 220 load calculations which assumes almost all of the home's appliances are on at the same time, something that is highly unlikely. This may result in over building the electrical system at the homeowner's expense.

"The code allows for load management via the EMS to right-size the home's electrical system, saving the homeowner money on infrastructure cost.

"A PCS relies on microprocessors that allow higher power flows to the home's loads with more PV, more batteries and more bi-directional EV chargers. The modern home uses a lot of power and will use even more power in the future. EMS and PCS are required to balance a home's power flows with the floodgates of innovation and tax credits included in the Inflation Reduction Act."

NEC 2023 vs. NEC 2020

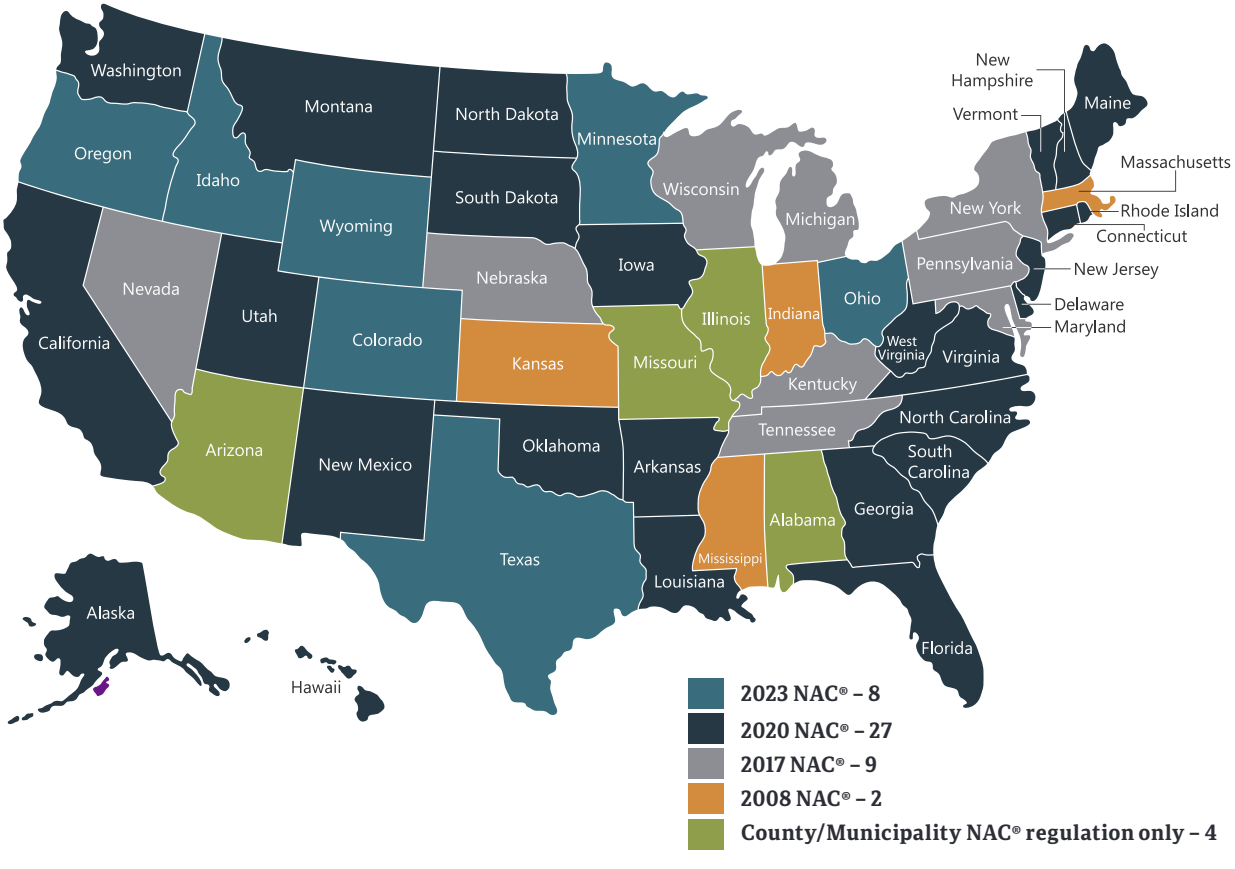
Changes from NEC 2020 to NEC 2023 are minor in terms of impact on system design and installation, but the update is thematically significant: 705.13 has been moved to 750, and filed under energy management systems (EMS).

Amarhanow: "Reading through the text you get the sense that EMS both ties together the residential and commercial space too."

You also get the sense that 1) PCS is fast-becoming a commonly accepted portion of code, and 2) it is a much simpler way to integrate code-compliant DERs at home and avoid main panel upgrades.

Amarhanow: "We see the load controls section in NEC 2023 becoming prevalent with different AHJs across the country — basically independent of region. We expect to see it cropping up in the Midwest, the East Coast and a lot in the Southeast"

NEC® in effect 3/1/2024



NEC 2023 Code Language	FranklinWH Explains
705.13: An EMS in accordance with 750.30 shall be permitted to limit current and loading on the busbars and conductors supplied by the output of one or more interconnected electric power production or energy storage sources.	EMS and PCS guidance relocated to 750.30.
750.30 Energy Management Systems Energy management systems shall be permitted to monitor and control electrical loads and sources in accordance with 750.30(A) through (C).	EMS monitors and controls system-wide CTs and relays.
A. Load Shedding Controls An energy management system shall not override the load shedding controls put in place to ensure the minimum capacity for the following: 1. Fire Pumps 2. Emergency Systems 3. Legally required standby systems 4. Critical operations power systems.	N/A for residential products.
B. Disconnection of Power An emergency management system shall not cause disconnection of power to the following: 1. Elevators, escalators, moving walks, or stairway lift chairs. 2. Positive mechanical ventilation for hazardous (classified) locations. 3. Ventilation used to exhaust hazardous gas or reclassify an area. 4. Circuits supplying emergency lighting. 5. Essential electrical systems in health care facilities.	N/A for residential products.
C. Capacity of Branch Circuit, Feeder, or Service An energy management system shall not cause a branch circuit, feeder, or service to be overloaded. If an EMS is used to limit the current on a conductor, 750.30(C)(1) through (C)(4) shall apply.	EMS shall not cause a branch circuit, feeder, or service to be overloaded. Can provide overcurrent protection by PCS or OCPD.
(1) Current Setpoint A single value equal to the maximum ampere setpoint of the EMS shall be permitted for one or more of the following: (1) For calculating connected load per 220.70. (2) For the maximum source current permitted by EMS control.	EMS shall limit load to enable a smaller than calculated value to be assumed for sizing electrical service. **MPU avoidance and nuisance tripping avoidance.**
(2) System Malfunction The EMS shall use monitoring and controls to automatically cease current flow upon malfunction of the EMS.	EMS to stop operation with malfunction or communication loss. Similar to interconnection requirements. Everything shuts down as a precaution.
(3) Settings Adjustable settings shall be permitted if access to the settings is accomplished by at least one of the following: (1) Located behind removable and sealable covers over the adjustment means. (2) Located behind a cover of door that requires the use of a tool to open. (3) Located behind locked doors accessible only to qualified personnel. (4) Password protected with password accessible only to qualified personnel. (5) Software that has password protected access to the adjusting means accessible to qualified personnel only.	Adjustments by qualified personnel only.
(4) Marking The equipment that supplies the branch circuit, feeder, or service shall be field marked with the following information: (1) Maximum current setting (2) Date of calculation and setting. (3) Identification of loads and sources associated with the current limiting feature. (4) The following or equivalent wording: "The setting for EMS current limiting feature shall not be bypassed." The markings shall meet the requirements in 110.21(B) and shall be located such that they are clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.	Clearly call out commissioned setpoints for EMS.
Section 702.4 – Capacity and Rating 2) Automatic Load Connection. If the connection of load is automatic, an optional standby system shall comply with 702.4(A)(2)(a) or (A)(2)(b) in accordance with Parts I through IV of Article 220 or by another approved method.	Loads connected by optional standby systems must comply with below options:
(a) Full Load. The standby source shall be capable of supplying the full load that is automatically connected.	All connected loads must be energized by the ESS. Not a practical scenario. No one turns on all their appliances at once.
(b) Energy Management System (EMS). Where a system is employed in accordance with 750.30 that will automatically manage the connected load, the standby source shall have a capacity sufficient to supply the maximum load that will be connected by the EMS.	EMS must manage connected load to stay within continuous amperage of the standby source output.

EMS: The Brains of Home Energy

Homeowners often purchase PV to reduce their electrical bills, batteries to provide backup power, and generators for long term outage security. The addition of other energy sources and the growing complexity of utility billing methods, such as Time of Use (TOU), means that today's homes need intelligent energy management. The energy management system (EMS) is the brain of today's solutions, managing and coordinating power sources to meet homeowner needs.

A multi-function gateway with robust hardware to enable high capacity electrical connections, coupled with an advanced EMS, helps keep home energy investments valuable during the warranty term and beyond. It's highly likely that most homes will have EVs by the end of the 10- to 15-year warranty term. That means managing EV chargers for most cost efficient use. Other alternative energy sources might eventually be added to work alongside solar as well.

Amarhanow: "Future proof compatibility for systems that are installed tomorrow can enable compatibility with future bidirectional EV chargers after just a firmware update."

EMS: The Brains of Home Energy

Installing a robust and expandable EMS now will help that homeowner avoid electrical service upgrades in the future.

Smart panels, with an integrated EMS, offer high resolution controls and usage data for every circuit in the home. They're truly 21st century tech, however that high resolution smart panel typically is associated with high installation costs for existing homes.

Key components

- **Energy Management System |** The EMS receives the current reported by the current transformers (CTs) and limits the power current as required. Loads may be shed to limit current.
- **Backed up bus |** The bus for backup power provides space for PV, batteries, EV chargers or other loads.
- **Intelligent circuits.** See **p. 13** for more
- **Optional generator input.**

BESS: The Heart of Home Energy

Battery Energy Storage Systems (BESS) are important for both efficient energy storage and load balancing.

Load balancing & peak shaving

A BESS stores excess energy generated during periods of low demand or from renewable sources, ensuring this energy can be utilized during peak demand periods. This helps balance the load, reduce strain on the main electrical grid, and maintain a stable power supply.

Additionally, BESS plays a crucial role in peak shaving, where stored energy offsets high electricity demand and manages energy costs. Homeowners can significantly reduce their reliance on the grid, maximize the use of renewable energy, and achieve greater energy independence.

PCS optimization

PCS further optimizes the BESS and EMS by dynamically adjusting load distribution to prevent overloading the main panel.

The PCS can integrate the various energy sources. By coordinating their use, the PCS can ensure efficient energy management and continuous power supply.

Ultimately, combining a PCS, BESS, and multiple energy sources, creates a robust and sustainable energy management solution that maximizes efficiency, reduces costs, and promotes the use of renewable energy, making the BESS a cornerstone of the home energy management system.

Why AC Coupling?

Stackable power

AC coupling means stackable power. For times when there's extraordinarily large home loads, AC coupled power allows the PV output and the battery output to be stackable or additive.

Homes typically use more power during the sunniest parts of the day when PV is producing. That same sun heats up the house and increases HVAC load. AC coupled batteries can surge in output in addition to the steady PV output to meet large occasional loads.

Stackability helps homeowners save money by not overbuilding the system in anticipation of occasional large loads. It also allows for the addition of generators.

Easier to service

DC coupled PV and battery systems are affordable because there are fewer power electronics components. Only one inverter handles both the PV and the battery — this means potentially a single point of failure. For homes with limited off-grid power demand and more budget-focused installations, DC coupled may be the way to go.

In most cases, troubleshooting DC coupled systems would be complex because DC voltages may vary across a single system.

With AC coupled systems, it is easy to see which piece of equipment is malfunctioning if it does not output 120V. Just check for 120V via multi-meter or remotely via FleetView — no temperamental DC voltages or API integrations.

High reliability is also key. 100% uptime frees busy installers to focus on their core business rather than foregoing income on new projects for service calls. Spreading the reliability requirements across each AC coupled source maximizes resiliency.

DER integration

AC coupled ESS provides 3 key benefits for the PV system and other DER, such as EV chargers or a generator, under NEC 750:

Grid forming. The battery inverter allows a "grid following" PV inverter to power on.
Off-grid capabilities for any PV inverter.
Black start capabilities for any PV inverter.

Import and Export Limitations

Power control systems enable full control of all the power in the home including PV and ESS. A PCS can limit the PV exported to the grid or prohibit ESS charging from the grid.

Imports

Certain utilities restrict or prohibit how much power a DER system draws from the grid. To prevent exceeding this limit, you can institute a ceiling within the PCS, or set a rule that the ESS can only be charged by PV or a generator.

Amarhanow: "A utility's transformers may be near capacity with newly developed loads, and they may completely prohibit grid charging of the ESS even if it is scheduled during off peak periods.

"If your utility is pretty restrictive and says you cannot charge from the grid at all, set this limit to zero in the PCS.

"If the utility allows you to charge a battery up to 5 kW from the grid, just add that setting during commissioning."

Exports

There are multiple export limitations for both PV and ESS.

PV example: You may need a larger 20+ kW PV system while the utility only allows exports up to 10 kW. A PCS with built-in CTs will ensure the exports stay under that cap. Entering these PCS functions guarantees that the system will never export the power above the setpoint to the grid.

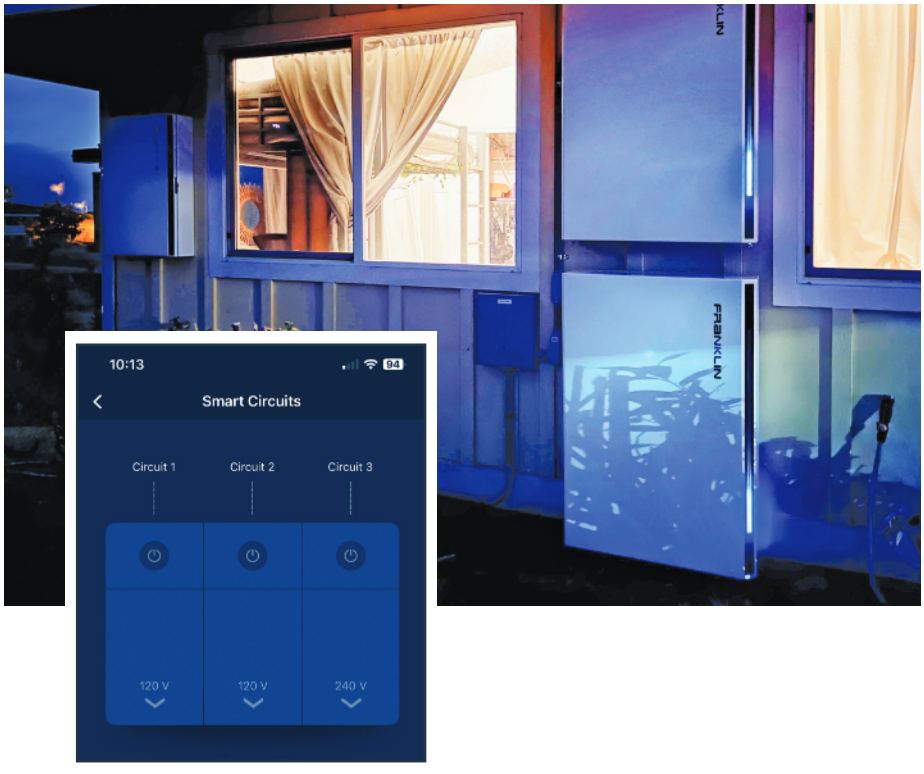
Amarhanow: "Make sure your system is sized properly so that you have additional batteries and load to soak up that extra overhead PV that might need to be curtailed. It is all performance certified; it is third-party verified through your nationally recognized testing laboratory."

ESS example: Under most circumstances it is not economical to export home ESS power to the grid. The installed cost of the hardware may be $0.50, so export credits would need to exceed that value. However, in states such as California that moved to a Net Billing Tariff, there are early evening hours that pay up to $3 per kWh for exporting ESS to the grid.

Intelligent Circuits

Intelligent circuits that control loads are not just acceptable under code, they are now crucial to future-proofing home solar and storage.

Intelligent circuits are needed to manage and shed loads to avoid nuisance tripping and to avoid main panel upgrades.



EMS vs. smart loads panel

An EMS can include intelligent circuits, which is different than a smart loads panel. This is an important distinction.

A smart loads panel with intelligent circuits can control specific home loads in synchronization with power availability. Intelligent circuits are geared toward a home's largest loads, such as air conditioning, pool pump, or EV.

Multi-use load management devices offer not only load shedding capabilities, like turning off the lights or an HVAC system, but also the ability to serve as connection points for bi-directional EV chargers or other generation sources such as fuel cells that emerge in the future.

Amarhanow: "Through our study, 75% of the home loads are consumed by 3 to 5 major appliances, like an oven, swimming pool, HVAC, electric water heater, etc. Therefore, there's no real demand to control every electrical circuit.

"With careful design, a few controllable intelligent circuits will greatly reduce home energy consumption and extend battery life during an off-grid situation, which result in substantial cost savings compared to a full MPU."

MPU Avoidance

Main Panel Upgrade (MPU) avoidance is a strategy employed to circumvent the need for upgrading a home's electrical panel when installing new, high-demand appliances.

Upgrading a main panel can be costly and time consuming, often requiring significant modifications to the existing electrical infrastructure.

A PCS is an effective method for MPU avoidance by becoming the central panel for managing varied power sources while the main panel remains the interface to the utility grid.

For instance, a PCS can monitor real-time power consumption and dynamically adjust the load distribution to ensure the main panel is not overloaded. During peak usage periods, the PCS can prioritize essential loads and temporarily reduce power to non-critical appliances, thus keeping the total load within safe limits.

Not all states have adopted PCS rules, but there are solutions in the market that employ other strategies. An intelligent panel with a larger busbar provides overcapacity for new loads without impacting the main panel, also avoiding an MPU.

The Multi-Source Energy Future

A PCS brings energy freedom and choice. With PCS, homeowners can integrate an increasing variety of energy sources to intelligently support the growing need for more — reliable and cost-effective — home power.

PV arrays are a critical component of home energy production, and batteries store that power for times when PV isn't producing. However, longer outages during weather emergencies can last for days and cut solar production. Generators are a power source that can help households during those times.

The adoption of EVs is also creating not just a need to charge those vehicles but to accept charging from them when needed. Vehicle-to-home (V2H) is gaining more exposure within the home energy sector.

Meanwhile, in different areas, other alternative sources are being investigated, such as home geothermal or wind turbine power generation.

All of those concepts are known, but there's always something new just over the horizon. That's why today's homes need an intelligent solution that is robust and can adapt and change in order to support our multi-source energy future.

The PCS is being supported by NEC because it's a **key** component to addressing that future.

Becoming a FranklinWH Installer

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2. Take the FranklinWH installer training courses and pass the exams (2 hours!).
3. You're certified!