# DOCKETED

| | |
|---|---|
| **Docket Number:** | 15-AAER-02 |
| **Project Title:** | Pool Pumps and Spa Labeling |
| **TN #:** | 222397-1 |
| **Document Title:** | Presentation - Motor Weighted Energy Factor Interpretive Tool |
| **Description:** | Commission staff developed an interpretive tool to present the proposed MWEF pool pump motor standard in terms of; motor efficiency, motor speed, and motor total capacity. Details of the proposed MWEF pool pump motor standard are available in the staff report. |
| **Filer:** | Sean Steffensen |
| **Organization:** | California Energy Commission |
| **Submitter Role:** | Commission Staff |
| **Submission Date:** | 1/30/2018 12:03:53 PM |
| **Docketed Date:** | 1/30/2018 |

# Motor Weighted Energy Factor Interpretive Tool

February 1, 2018

Sean Steffensen, P.E.

Appliances and Outreach & Education Office

Efficiency Division

# MWEF Interpretation Tool

- Commission staff developed an interpretive tool to present the proposed MWEF pool pump motor standard in terms of;
  - motor efficiency,
  - motor speed,
  - and motor total capacity
- Details of the proposed MWEF pool pump motor standard are available in the staff report.

# Proposed Standard vs. Test Score

- Proposed MWEF Standard sets a total energy budget based upon motor total capacity (hp).
  - Proposed motor standard varies per motor type.
  - Standard-size self-priming standard shown below

**Proposed Standard**    $MWEF = -2.30*\ln(hp/1.4)+6.59$

- The motor test score equation verifies the motor performs within the energy budget.

**Proposed Test Score**    $$MotorWEF = \frac{\sum_i W_i * \sqrt[3]{T_i * N_i * n_{pump} * 91.8} * \frac{60}{1,000}}{\sum_i W_i * \frac{P_i}{1,000}}$$

# Proposed MWEF Standard vs. Motor Score

- A minimally compliant pool pump motor will use no more than its energy budget.

**Proposed Standard**  **Proposed Test Score**

$$MWEF \geq MotorWEF$$

$$-2.30*\ln(hp/1.4)+6.59 \geq \frac{\sum_i W_i * \sqrt[3]{T_i * N_i * n_{pump} * 91.8 * \frac{60}{1,000}}}{\sum_i W_i * \frac{P_i}{1,000}}$$
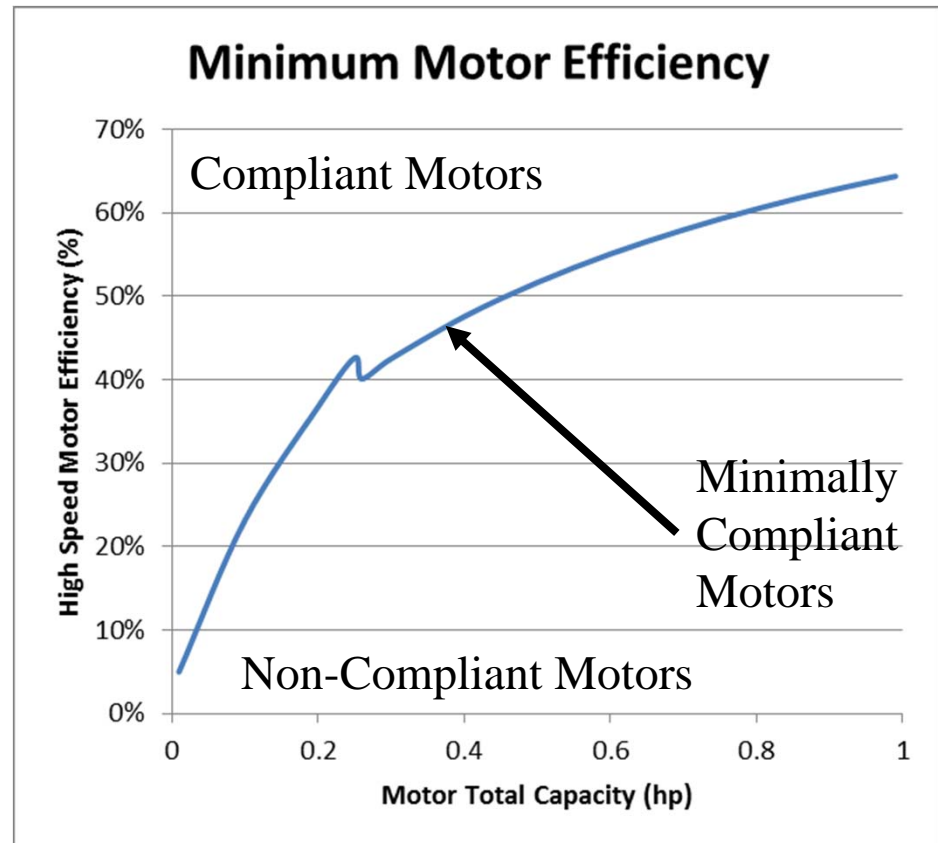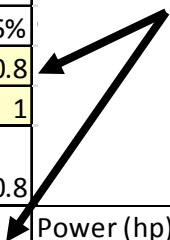
- The above equation can be expressed in motor total capacity, high and low speed efficiency, and motor speed.

# Small Self Priming Motor Example

| Motor Parameters | Motor | |
|---|---|---|
| Pump Efficiency | 55% | |
| Nominal hp | 0.8 | |
| Service Factor | 1 | |
| Motor Total Capacity | 0.8 | |
| | RPM | Power (hp) |
| Full Speed | 3450 | 0.8 |
| Hi Speed | 3450 | 0.8 |
| Low Speed | N/A | N/A |
| Minimum MWEF score | 3.63 | |
| **Motor Design Check** | | |
| Minimum Motor Efficiency | 60% | |

**User Inputs**



Minimum Motor Efficiency

Compliant Motors

Minimally Compliant Motors

Non-Compliant Motors

# Standard Size Self Priming Motor Example

| Motor Parameters | Proposed Motor |
|---|---|
| Pump Efficiency | 55% |
| Nominal hp | 1 |
| Service Factor | 1 |
| Motor Total Capacity | 1 |
| Weighting factor (high speed) | 0.2 |
| Weighting factor (low speed) | 0.8 |
| Conversion hp to watts | 746 |
| Minimum MWEF Score | 7.36 |
| Curve C factor | 0.0082 |
| Conversion for hp and ft-gpm | 3956 |

**Motor Design Check (Point Check)**

| | RPM | Power (hp) | Motor Efficiency |
|---|---|---|---|
| Full Speed | 3450 | 1 | 80% |
| Hi Speed | 3450 | 1 | 80% |
| Low Speed | 1725 | 0.125 | 58% |

**User Inputs**



High Speed Efficiency vs. Low Speed Efficiency

Compliant Motors

Non-Compliant Motors

Minimally Compliant Motors at 1 hp

6
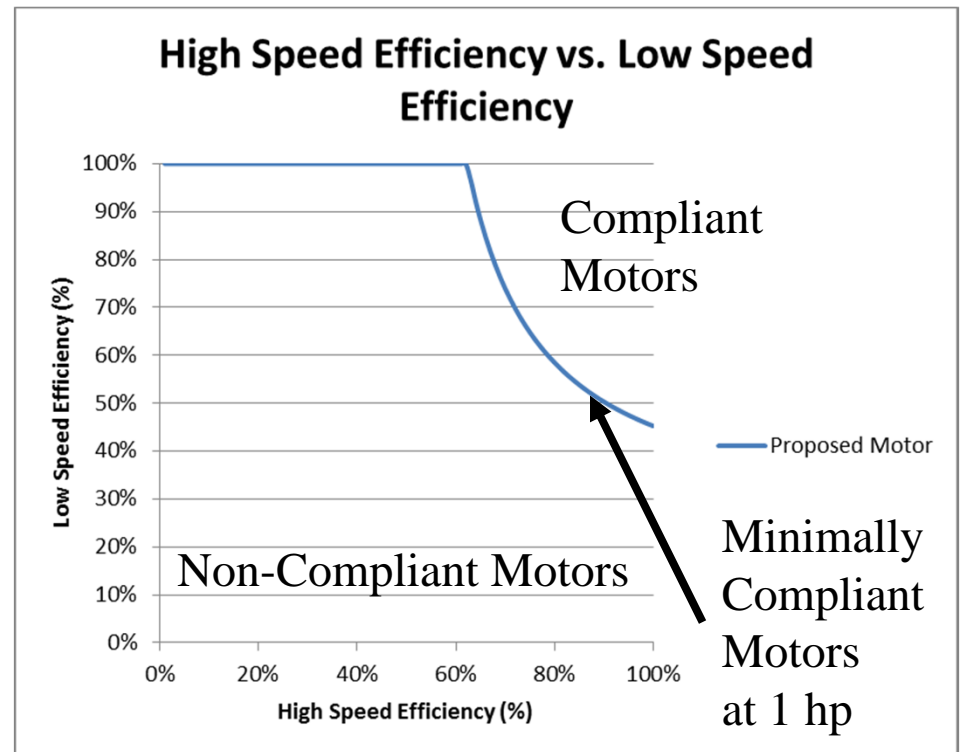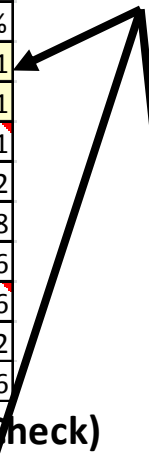
# Non Self Priming Motor Example
# (single speed)

| Motor Parameters | Motor | |
|---|---|---|
| Pump Efficiency | 55% | |
| Nominal hp | 0.8 | |
| Service Factor | 1 | |
| Motor Total Capacity | 0.8 | |
| | RPM | |
| Full Speed | 3450 | 0.8 |
| Hi Speed | 3450 | 0.8 |
| Low Speed | N/A | N/A |
| Minimum MWEF score | 3.35 | |
| **Motor Design Check** | | |
| Minimum Motor Efficiency | 56% | |

**User Inputs**



Minimum Motor Efficiency

Compliant Motors

Minimally Compliant Motors

Non-Compliant Motors

7
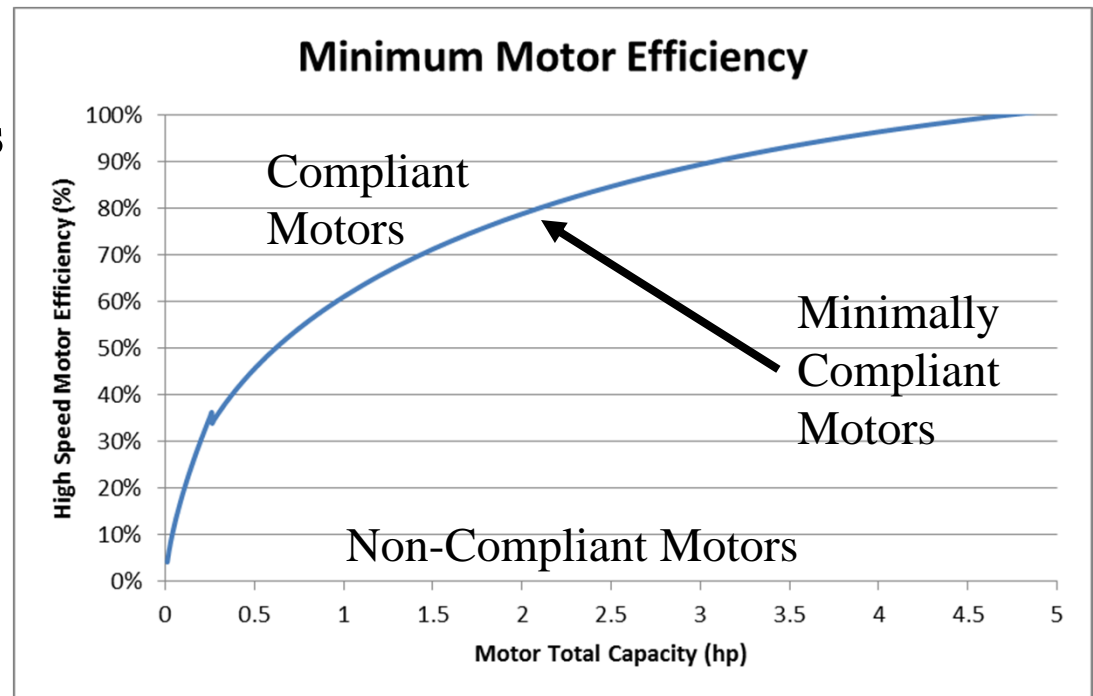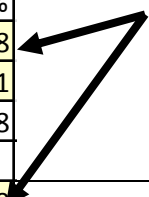
# Non Self Priming Motor Example
# (2 or more speed)

| Motor Parameters | Proposed Motor |
|---|---|
| Pump Efficiency | 55% |
| Nominal hp | 1 |
| Service Factor | 1 |
| Motor Total Capacity | 1 |
| | |
| Weighting factor (high speed) | 0.2 |
| Weighting factor (low speed) | 0.8 |
| Conversion hp to watts | 746 |
| Minimum MWEF Score | 3.16 |
| Curve C factor | 0.0082 |
| Conversion for hp and ft-gpm | 3956 |
| **Motor Design Check** | |

| | RPM | Power (hp) | Motor Efficiency |
|---|---|---|---|
| Full Speed | 3450 | 1 | 65% |
| Hi Speed | 3450 | 1 | 65% |
| Low Speed | 1725 | 0.125 | 15% |

**User Inputs**

High Speed Efficiency vs. Low Speed Efficiency

Compliant Motors

Minimally Compliant Motors at 1 hp

Non-Compliant Motors

Proposed Motor

8
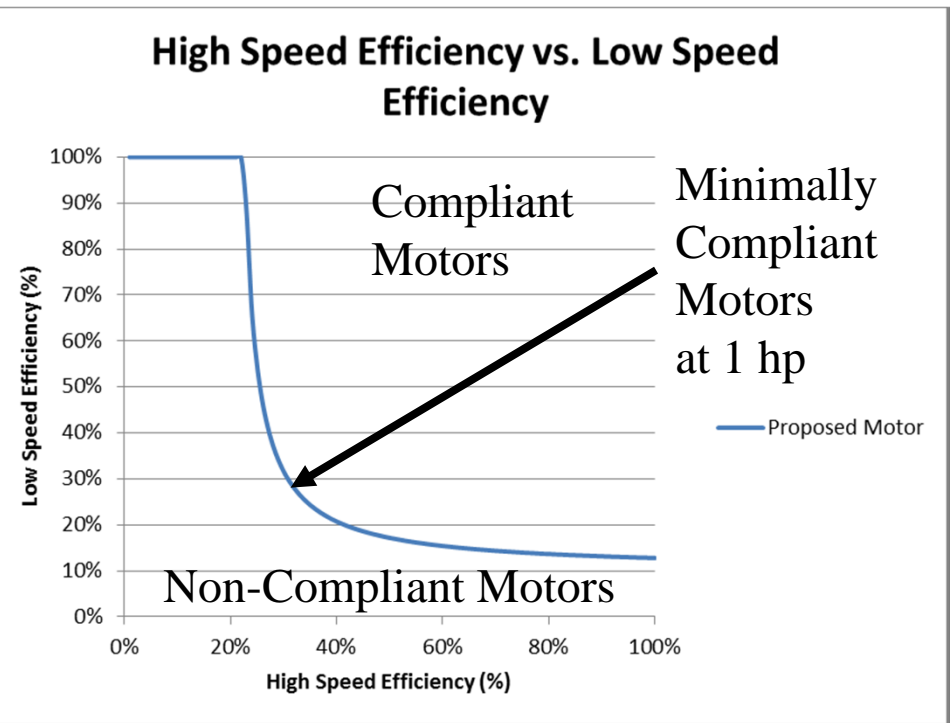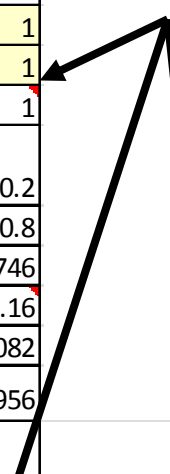
# References from Commission Staff Report

- ## Staff Report Information:

  - Steffensen, Sean, Jessica Lopez, and Ben Fischel. 2017. Second Revised Staff Analysis of Efficiency Standards for Pool Pump Motors, and Spas. California Energy Commission. Publication Number: CEC-400-2016-002-SD3

  - http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-02/TN220120_20170712T095947_Second_Revised_Analysis_of_Efficiency_Standards_for_Pool_Pumps.pdf

### Table 6-3: Proposed Standards for Replacement DPPP Motors

| Replacement Pool Pump Motor Unit Type | Proposed Minimum Motor Weighted Energy Factor According to Modified CSA C747-09 Test Procedure | | |
|---|---|---|---|
| | **Total Motor Capacity (Horsepower)** | **Motor Phase** | **Minimum Allowable MWEF Score** |
| Replacement Standard-Size Self-Priming Pool Filter Pump Motors | =>1.0 hp and <5.0 hp | Single | $MWEF = -2.30*ln(hp/1.4)+6.59$ |
| Replacement Small-Size Self-Priming Pool Filter Pump Motors | < 1 hp | Single | $MWEF = 5.55$ for hp <=0.26 hp, $-1.30*ln(hp/1.4)+2.90$ for hp >.26 hp |
| Replacement Non-Self-Priming Pool Filter Pump Motors | < 5.0 hp | Any | $MWEF = 4.6$ for hp <=0.26 hp, $-0.85*ln(hp/1.4)+2.87$ for hp >.26 hp |
| Replacement Waterfall Pump Motors | Any | Any | None |
| Replacement Pressure Cleaner Booster Pump Motors | Any | Any | $MWEF = .42$ |

Source: California Energy Commission

10

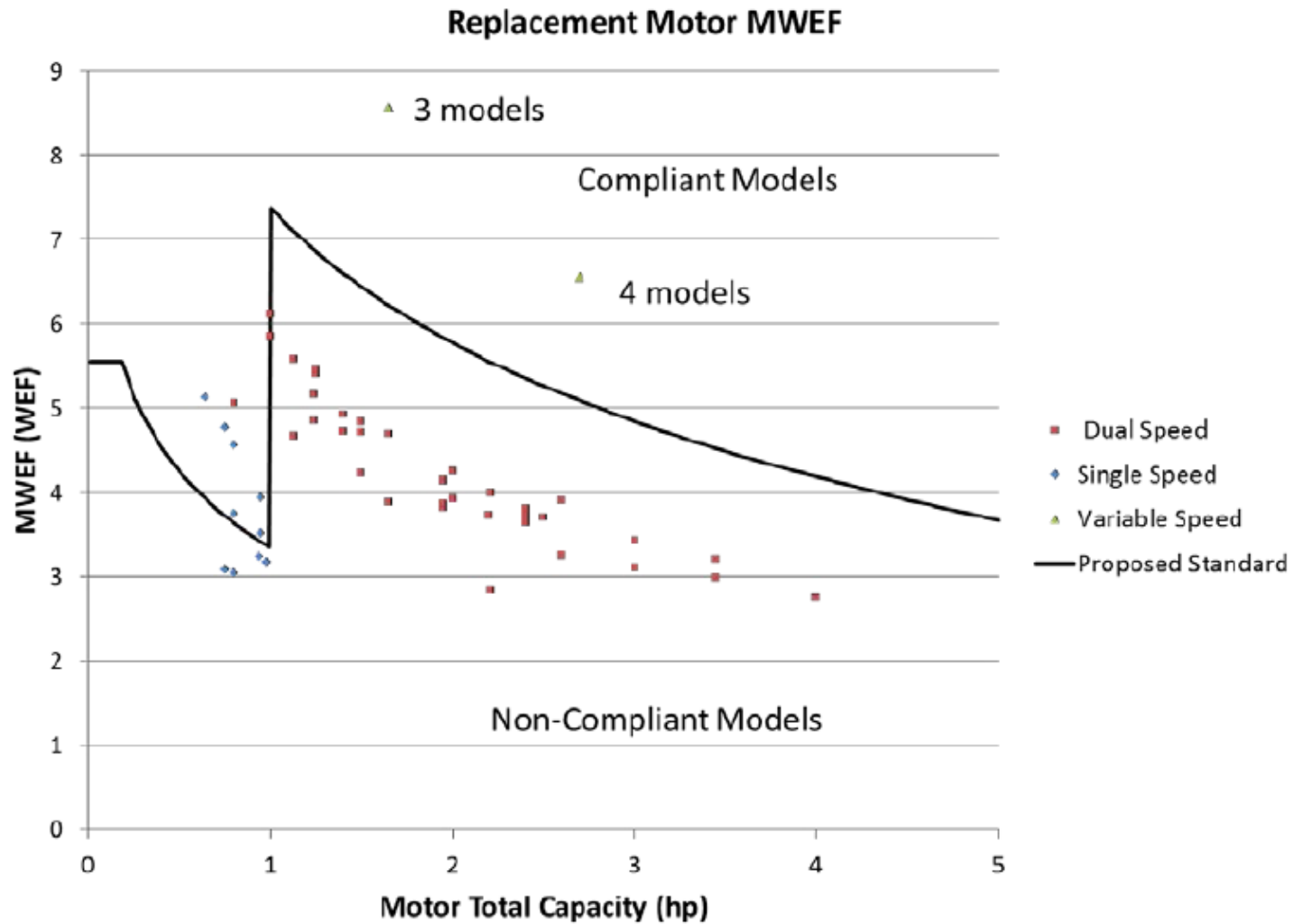## Figure 6-3: MWEF Scores for Motors Within Pool Pump and Motor Combinations
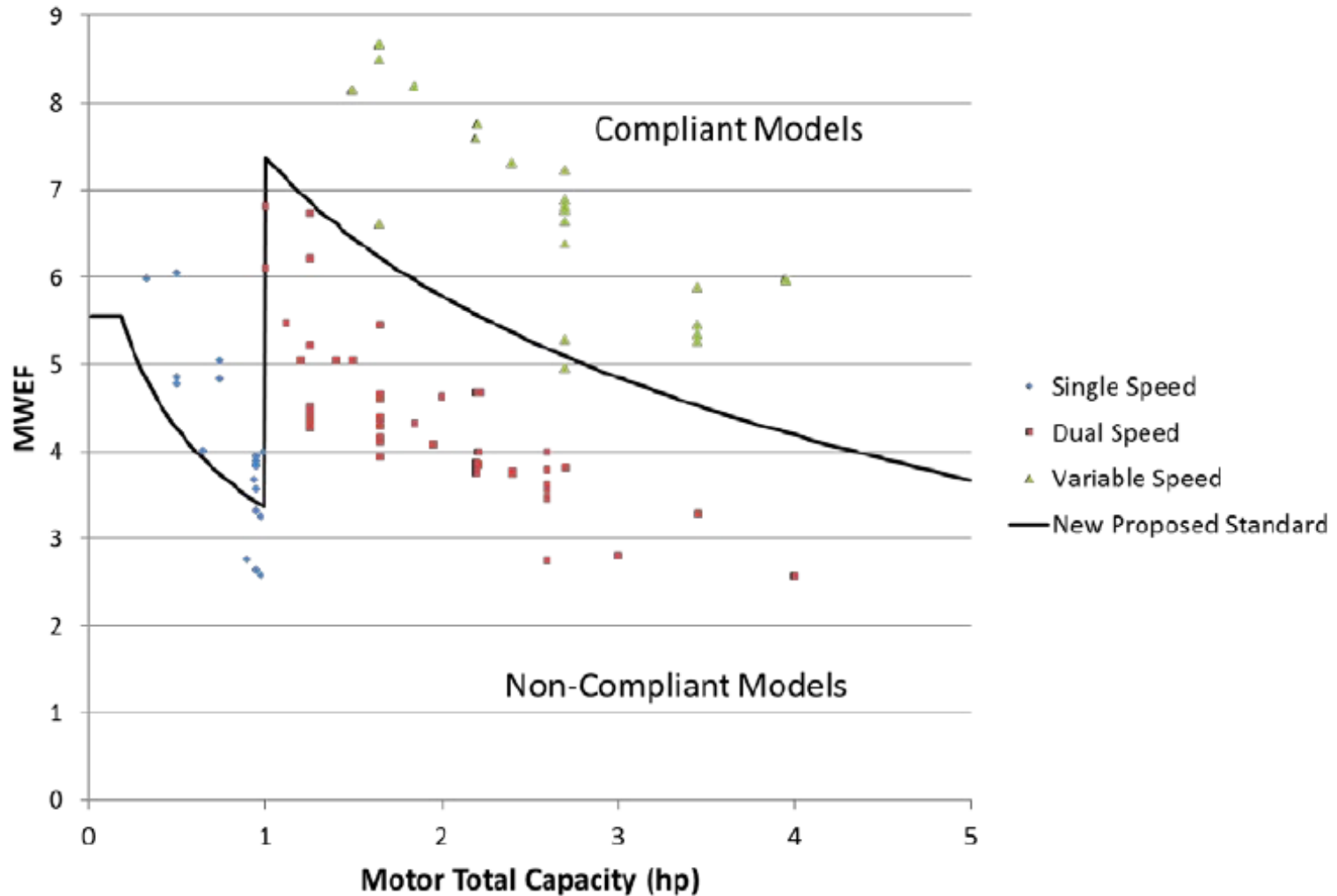


Source: California Energy Commission

**Figure 6-4: MWEF Scores for Replacement Residential Pool Pump Motors**



**Replacement Motor MWEF**

Source: California Energy Commission

**Table 6-4 Test Points and Weights for Energy Factor Calculation**

| Replacement Motor Design | Speed Configuration(s) | Number of Load Points (n) | Load Point (i) | Test Points | | |
|---|---|---|---|---|---|---|
| | | | | Motor Horsepower Output | Torque (ft-lb) | Speed |
| Replacement self-priming pool filter pump motors and replacement non-self-priming pool filter pump motors | Single-speed replacement dedicated-purpose pool pump motor and all replacement self-priming and non-self-priming pool filter pump motors not meeting the definition of two-, multi-, or variable speed replacement dedicated purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \dfrac{Motor\ Total\ Capacity \times 5252}{RPM}$ | Maximum Speed |
| | Two speed replacement dedicated purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $motor\ total > 1.5\ capacity$ or $HP_{low} \geq .062$ if $motor\ total \leq 1.5\ capacity$ | $T_{low} = T_{max} \times \left(\dfrac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified horsepower and torque values, if any. |
| | | | High | Motor Total Capacity | $T_{max} = \dfrac{(HP_{out} \times 5252)}{RPM}$ | Maximum Speed |

13

| | | | | | | |
|---|---|---|---|---|---|---|
| | Multi-speed and variable speed replacement dedicated-purpose pool pump motors | 2 | Low | HP associated with the specified torque and speed: $HP_{low} \geq .124$ if $motor\ total > 1.5\ capacity$ or $HP_{low} \geq .062$ if $motor\ total \leq 1.5\ capacity$ | $T_{low} = T_{max} \times \left(\dfrac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. |
| | | | High | $HP_{out} \geq Motor\ total \times \left(\dfrac{8}{10}\right)^3\ capacity$ | $T_{max} = \dfrac{(HP_{out} \times 5252)}{RPM}$ | Lowest speed capable of meeting the specified HP and torque values. |
| Replacement Waterfall Pump Motors | Single-speed replacement dedicated-purpose pool pump motor | 1 | High | Motor Total Capacity | $T_{max} = \dfrac{Motor\ total\ capacity \times 5252}{RPM}$ | Maximum Speed |
| Pressure Cleaner Booster Pumps | Any | 1 | High | $HP_{low} \geq .61$ | $T_{low} = T_{max} \times \left(\dfrac{HP_{low}}{HP_{max}}\right)^2$ | Lowest speed capable of meeting the specified HP and torque values. |

14

Source: California Energy Commission