



# Evaluation of the Cost Impact of 2015 IBC Prescriptive Code Changes

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# BIM: What is Building Information Modeling?

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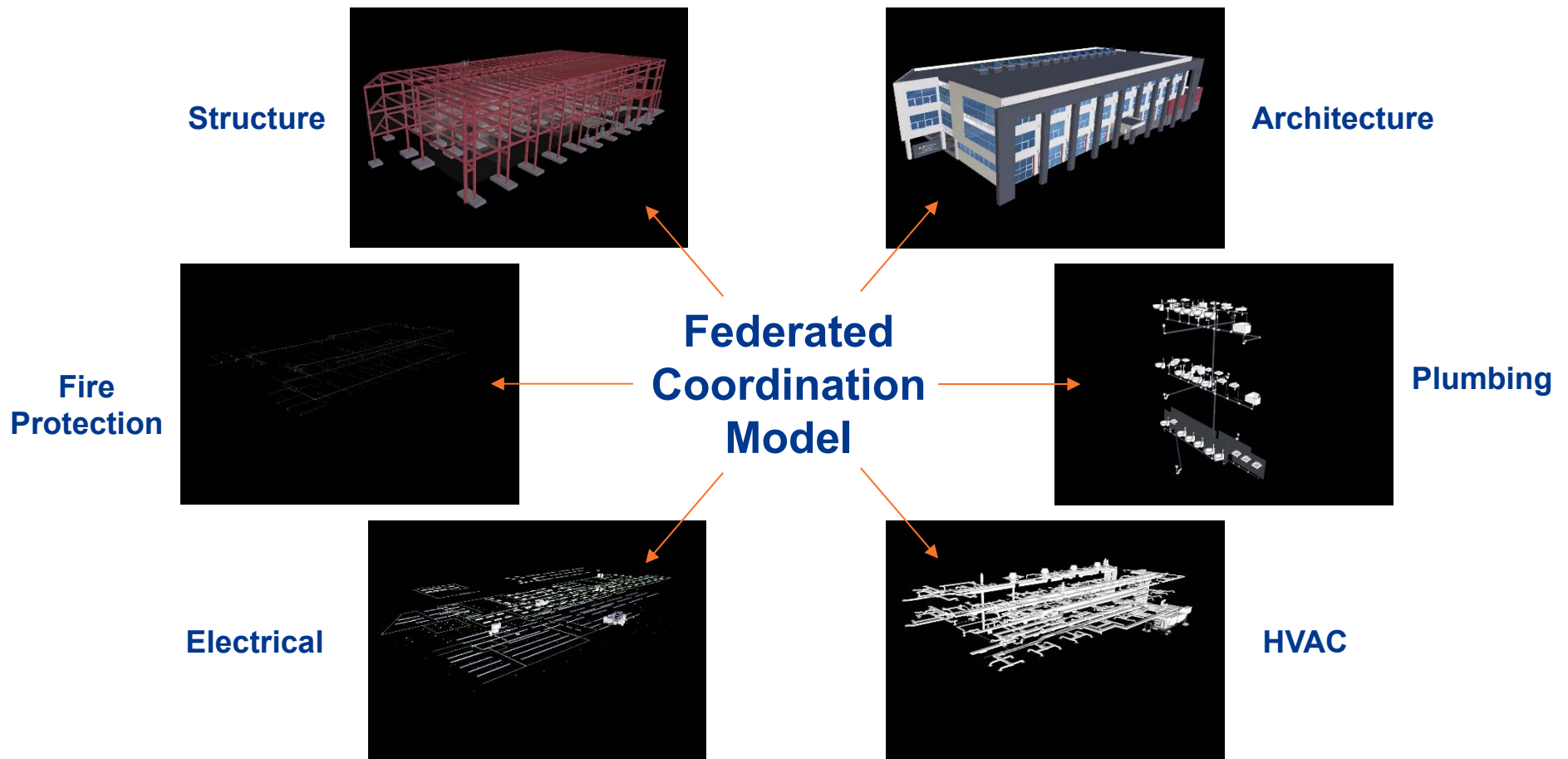
1. An intelligent 3D model with embedded **information** and specifications for all the material and system selections of a project, as well as their associated properties.
2. Virtual collaboration resource which aids in the decision making and information exchange process throughout the lifecycle of a building from conception to facilities management.

# BIM: Benefits of BIM?

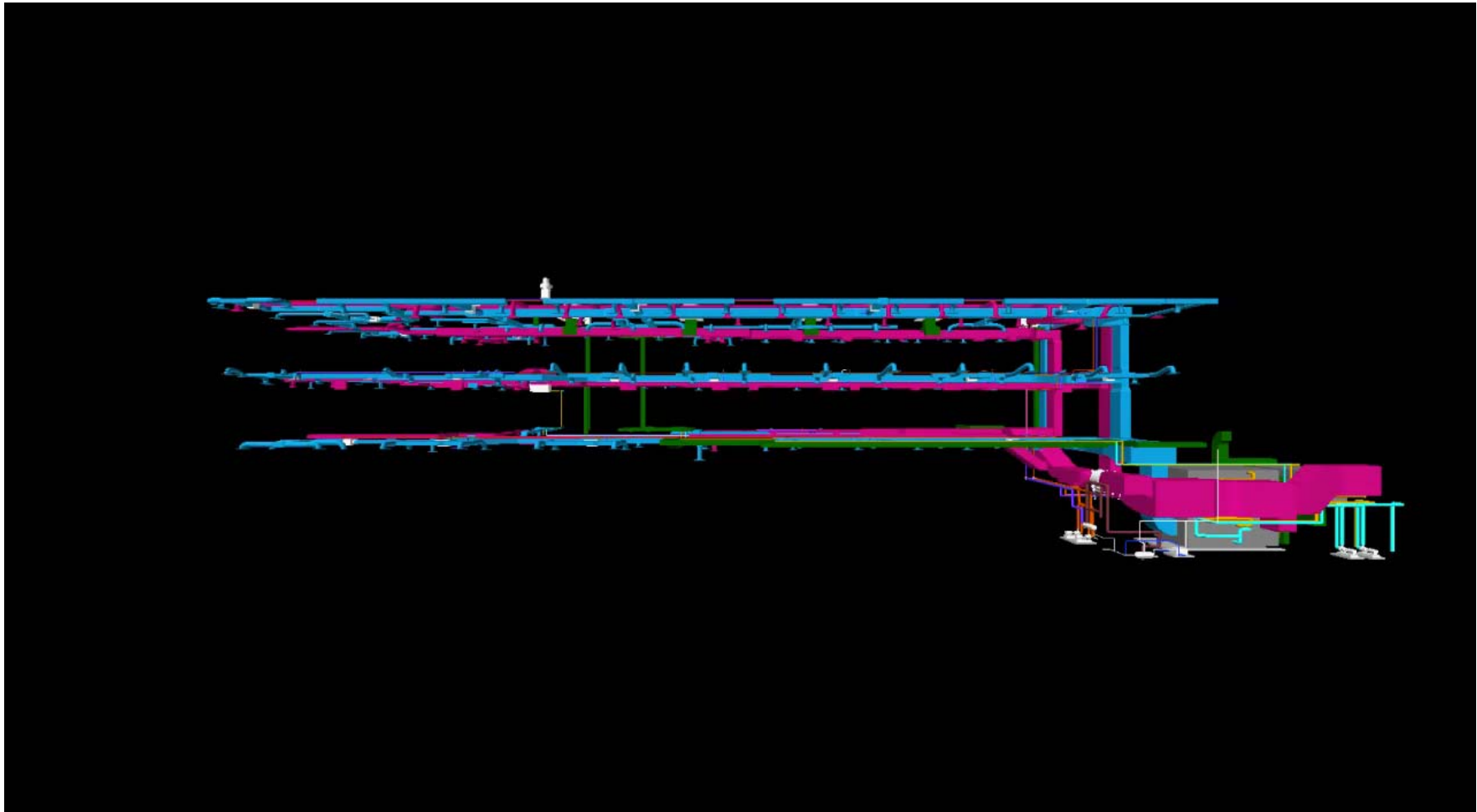
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1. Enhanced collaboration capabilities among all members of a project team.
2. Coordination of all building systems and the testing of design alternatives prior to construction.
3. Ability to tie model to schedule for visualization and quality assurance purposes. (4D BIM)
4. Greater access to live data regarding building material quantities for more accurate cost estimates. (5D BIM)
5. Creation of more accurate and thorough as-built documents.

# BIM: Collaborative Platform



# BIM: HVAC Model of Rinker Hall

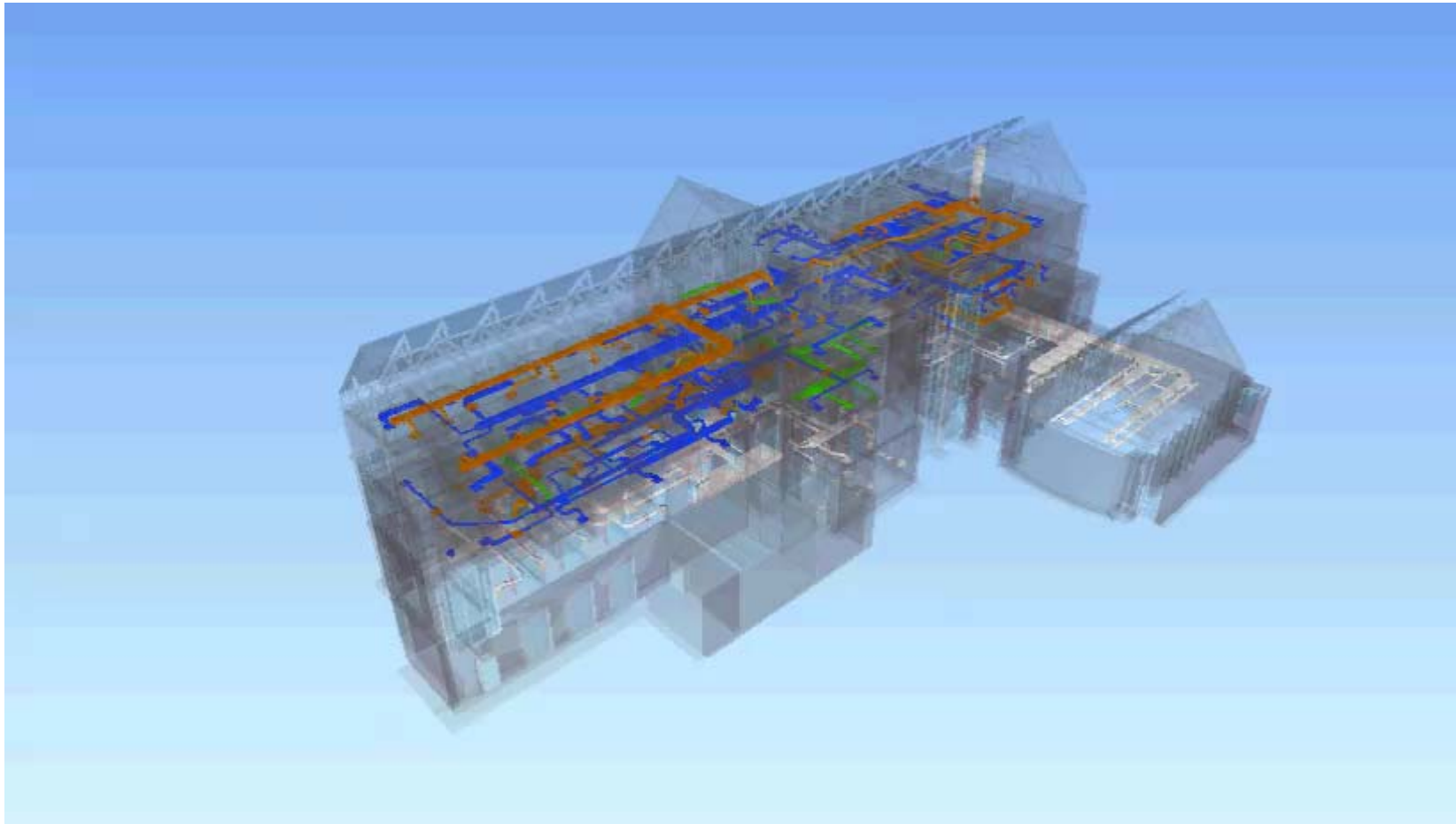


# BIM: Building Information Modeling

- Federated Multi-Disciplinary Model



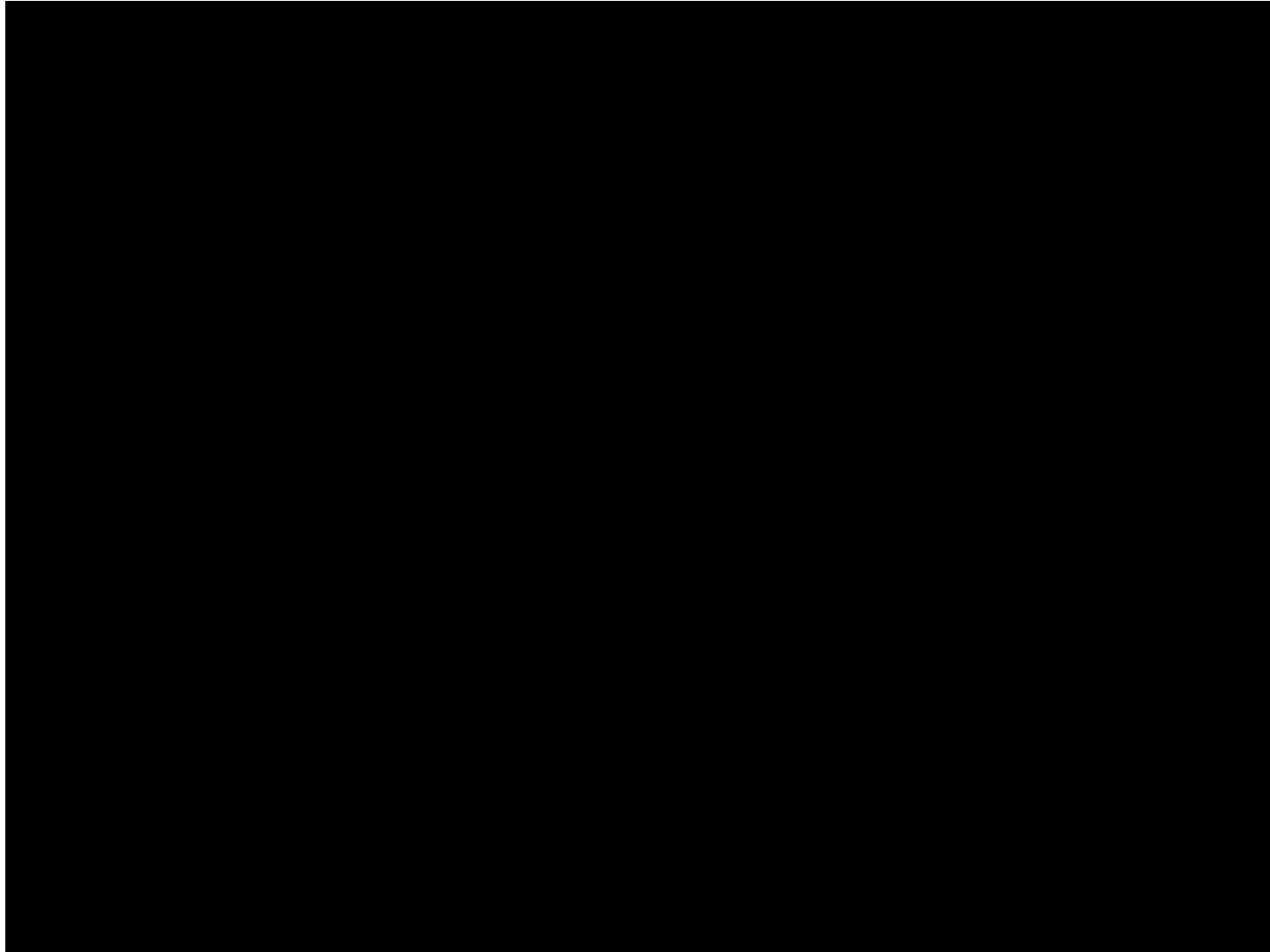
# BIM: Embedded MEP Model of Gerson Hall





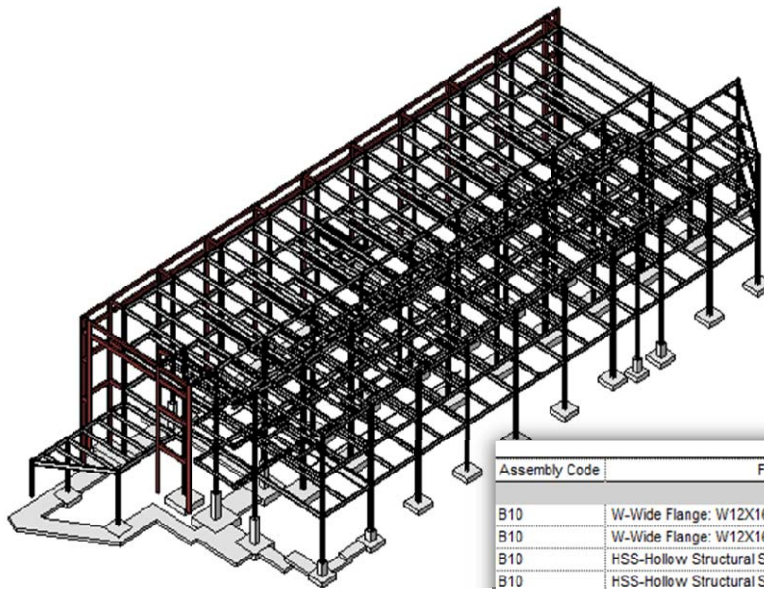
# BIM: Ramp Construction Simulation

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# BIM: Quantity Surveys

- Material quantity data built into model for instantaneous updates as the project changes.

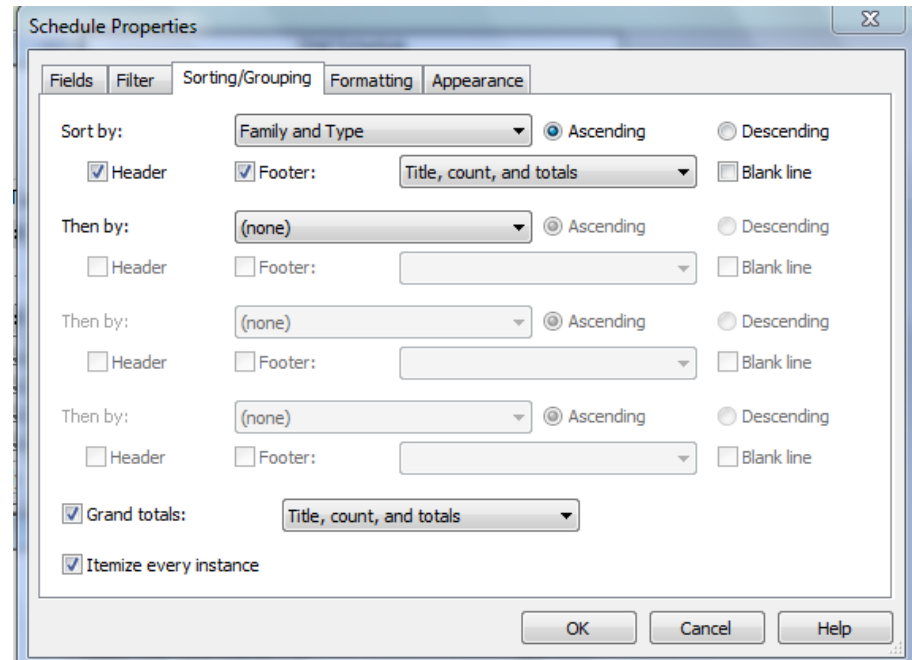
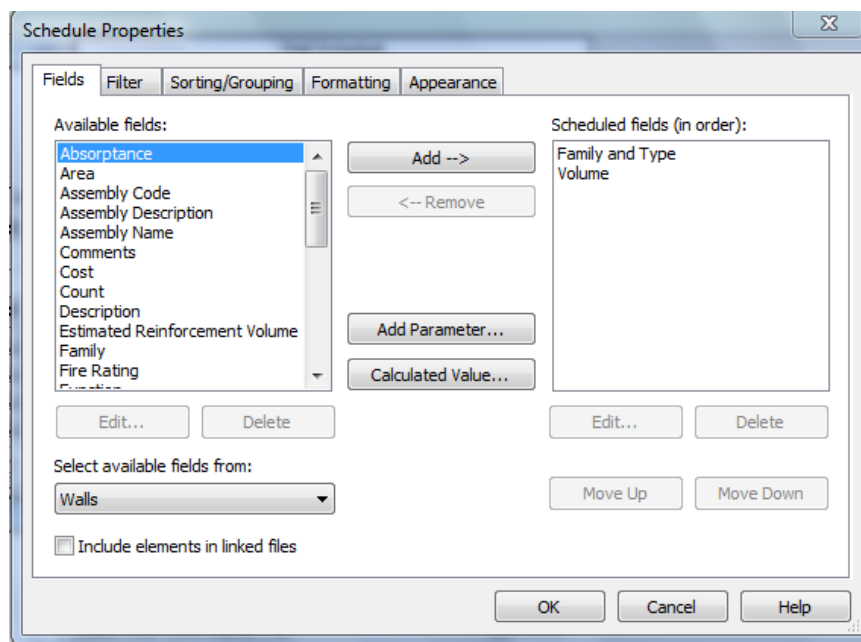


F7-84"x84"x18"						
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
A101010	Footings-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"		1
F7-84"x84"x18": 10						10

Structural Steel				
Assembly Code	Family and Type	Count	Length	Cost
B10	W-Wide Flange: W12X16-Rinker	1	12' - 11"	
B10	W-Wide Flange: W12X16-Rinker	1	12' - 11"	
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	5' - 0"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 9 5/16"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	9' - 10"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	11' - 7"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	26' - 11"	10.00

# BIM: Quantity Surveys

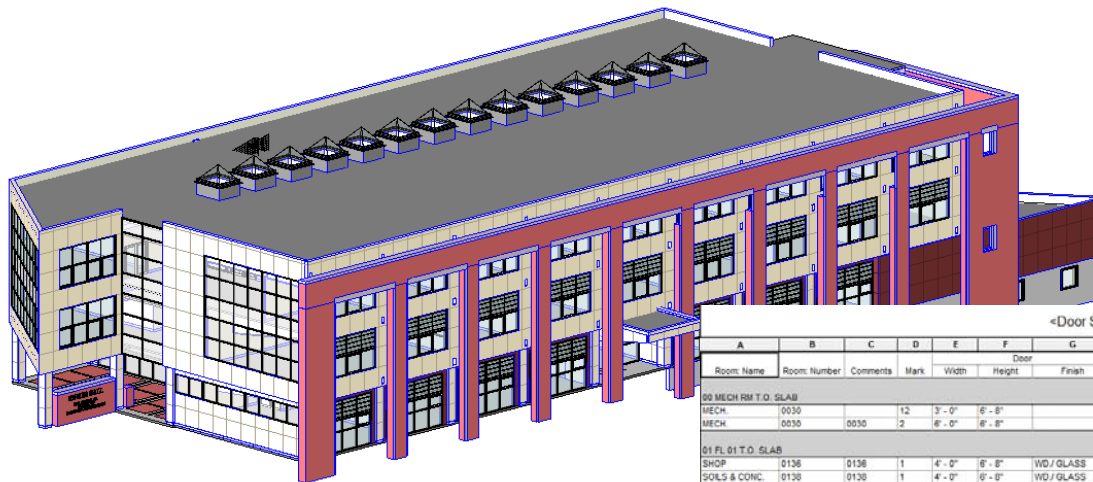
- A wide range of data fields within the BIM environment can be accessed and exported to show the specific information needed.



# BIM: Quantity Surveys

- Quantities can be exported from the model of any system and used to calculate cost.

<Room Schedule>									
A	B	C	D	E	F	G	H	I	
Room Nu	Room Name	Area	Floor Finish	Base Finish	Wall Finish	Ceiling Finish	Ceiling Height	Comments	
0030	MECH.	1420 SF							
0030A	ELEC. ROOM	251 SF							
0106	MEDIUM CLASSROOM	908 SF							
0110	LARGE CLASSROOM	1750 SF							
0110A	ELEC.	65 SF							
0115	STUDENT LOUNGE	471 SF							
0125	M.E.P STUDIO	1611 SF							
0134	SHOWER	75 SF							
0136	SHOP	274 SF							
0138	SOILS & CONC. LAB	706 SF							
0140	STRUCTURES STUDIO	1292 SF							
0140A	STORAGE	418 SF							
0141	INTERVIEW	100 SF							
0143	INTERVIEW	100 SF							
0145	MEN	224 SF							
0146	WOMEN	253 SF							
0146A	MECH. ROOM	66 SF							
0201	BM LAB	845 SF							



<Door Schedule>													
A	B	C	D	E	F	G	H	I	J	K	L	M	
Room Name	Room Number	Comments	Mark	Width	Height	Door	Finan	Type	Frame Type	Fire Rating	Hardware	Cost	Level
00 MECH RM T.O. SLAB													
MECH	0030		12	3'-0"	6'-8"			36" x 60"					00 MECH RM T.O.
MECH	0030		2	6'-0"	6'-8"			B		45			00 MECH RM T.O.
01 FL 01 T.O. SLAB													
SHOP	0138		1	4'-0"	6'-8"	WD / GLASS	A	H.M./PTD.		60 min	9		01 FL 01 T.O. SLA
SOILS & CONC.	0138		1	4'-0"	6'-8"	WD / GLASS	G	H.M./PTD.			4		01 FL 01 T.O. SLA
SOILS & CONC.	0138		2	6'-0"	6'-8"	ALUM./GLASS	D-Double	ALUM.			4		01 FL 01 T.O. SLA
STORAGE	0140A		140	2	6'-0"	6'-8"	ALUM./GLASS	D-Double	ALUM.		6		01 FL 01 T.O. SLA
INTERVIEW	0141		141	1	3'-0"	6'-8"	ALUM./GLASS	C	ALUM.		5		01 FL 01 T.O. SLA
CORRIDOR	C1990		143	1	3'-0"	6'-8"	ALUM./GLASS	C	ALUM.		5		01 FL 01 T.O. SLA
MECH ROOM	0146A		1	3'-0"	6'-8"	H.M./PTD.	L-FIRE RATED	H.M./PTD.		45 min	4		01 FL 01 T.O. SLA
CORRIDOR	C1990		4	3'-0"	6'-9 11/16"	ALUM./GLASS	D-Left	ALUM.			1		01 FL 01 T.O. SLA
CORRIDOR	C1990		5	6'-1"	6'-9 11/16"	ALUM./GLASS	D-Double	ALUM.			3		01 FL 01 T.O. SLA
CORRIDOR	C1990		6	3'-0"	6'-9 11/16"	ALUM./GLASS	D-Right	ALUM.			2		01 FL 01 T.O. SLA
MEDIUM CLASS	0106		1	6'-0"	6'-8"	WD / GLASS	K	H.M./PTD.			10		01 FL 01 T.O. SLA
LARGE CLASS	0110		2	6'-0"	6'-8"	WD / GLASS	K	H.M./PTD.			10		01 FL 01 T.O. SLA
ELEC.	0110A		3	6'-0"	6'-8"	H.M./PTD.	B	H.M./PTD.			45	21	01 FL 01 T.O. SLA
ELEC.	0110A		4	6'-0"	6'-8"	H.M./PTD.	B	H.M./PTD.			45	12	01 FL 01 T.O. SLA
LARGE CLASS	0110		1	3'-0"	6'-8"	H.M./PTD.	A.-6'x3'0"	H.M./PTD.		45 min	13		01 FL 01 T.O. SLA
WOMEN	0146		1	3'-0"	6'-8"	H.M./PTD.	E	H.M./PTD.			14		01 FL 01 T.O. SLA
MEN	0145		2	3'-0"	6'-8"	H.M./PTD.	E	H.M./PTD.			14		01 FL 01 T.O. SLA
STRUCTURES S	0140		3	3'-0"	6'-8"	WD / GLASS	G-6'x3'0"	H.M./PTD.			15		01 FL 01 T.O. SLA
STUDENT LOUN	0115		4	3'-0"	6'-8"	WD / GLASS	G-6'x3'0"	H.M./PTD.			15		01 FL 01 T.O. SLA
M E P STUDIO	0125		5	3'-0"	6'-8"	WD / GLASS	G-6'x3'0"	H.M./PTD.			15		01 FL 01 T.O. SLA

# ISSUES

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- The proposed research assesses the cost impact of the 2015 International Building Code changes to the 2012 International Building Code that are prescriptive in nature and that have the potential of adding cost to construction.

# STATEMENT OF WORK

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- **1. Review/analyze the 2015 I-Code changes to the 2012 I-Code to identify those code changes/provisions that are prescriptive in nature and have the potential of adding cost to construction.**
  - The listed consultants will participate in this process to help the research team with the specifics of the design changes.

# STATEMENT OF WORK

- **2. Review available literature/studies on the subject of estimating the costs of the code changes to the 2012 I-Codes including the ICC code proceedings/ code hearings. Information gathered from this task will be used to document potential costs for the code changes as identified in (1) and as applicable.**
  - The research team will conduct an extensive literature review on cost estimates due to Code changes.

# STATEMENT OF WORK

- **3. Estimating the additional construction cost of those provisions that are not covered under (2) using good engineering judgment and feedback from general contractors and consulting engineers.**
  - The listed consultants and general contractors will help the research team with the cost estimates for these changes.



# STATEMENT OF WORK

- **4. Use a standard set of baseline residential and commercial building designs for use to determine the cost impact of code changes.**
  - A recent study for the USDOE on the cost impact of the ASHRAE Standard 90-1-2013 changes used: 1) a small office building; 2) a standalone retail building; 3) a primary school; 4) a small hotel; and 5) a mid-rise apartment building as cost reference commercial buildings, since these type of buildings represented over 74% of new construction by floor area.

# STATEMENT OF WORK

- Another recent study by the NAHB on the estimated cost of the 20152 IRC changes used one-story and two-story houses on slab and basement foundations, since these type of houses represented approximately 85% of the last decade's new single-family construction. The houses were also deemed to have a gas furnace with central (electric) air conditioner in order to be representative of the majority of new US houses being built. Table 1 shows the adaptation of the NAHB Reference House Parameters proposed for this study.

Reference House	1	2
Square Feet	2,607	2,607
Foundation	Slab	Slab
Number of Stories	1	2
Number of Bedrooms	3	4
Number of Bathrooms	2	2.5
Garage, attached	2-car	2-car
Heat, Gas Furnace	Yes	Yes
Cooling, (Electric) central air	Yes	Yes
Hot Water, Gas 50 gallon tank	Yes	Yes
9 ft. Ceilings, 1 <sup>st</sup>	Yes	Yes
8 ft. Ceilings, 2 <sup>nd</sup>	n/a	n/a
Energy Star appliances	Yes	Yes
Laundry Room	Yes - Mudroom	Yes
Furnace Location	Attic	Attic
Water Heater Location	Interior	Garage
Window SF/% gross wall	360/18%	315/12%
Cladding*	Stucco, 4 sides	Stucco, 4 sides

\*Changed from Brick in NAHB version to Stucco

For the purposes of this study the five commercial buildings and a one-story and a 2-story house on slab foundation will be used as the initial prototypes.

# STATEMENT OF WORK

- **5. Building information modeling (BIM) will be used to develop digital sets of the permit-ready residential (2 houses) and five commercial/institutional buildings models.**

# STATEMENT OF WORK

- **6. Use BIM tools to produce for each of the prototype buildings for each of the 2012 and 2015 I-Codes:**
  - Schedule of Material Quantities (exportable to MS Excel)
  - Architectural 3D view and walk-through
  - Isolated Structural 3D view and walk-through
  - Isolated MEP/MEPF 3D view and walk-through

# STATEMENT OF WORK

- **7. Use the information in 6(a) and cost databases to produce cost estimates and extract cost impact of changes on the reference houses and commercial buildings.**
  - Sources of cost data will include R.S. Means Cost Data; distributors' or big box retailers' websites, and building contractors.
  - Cost estimates of the code changes that do not directly apply to the selected reference houses will be listed separately and can be added or subtracted from the aggregated costs for these reference houses.

# DELIVERABLES

- A report providing technical information on the problem background, results and cost implications of the prescriptive Code changes submitted by 15 December 2016.
- An analysis of individual code changes will also be provided in the Appendix.

# Cost Impact Analysis 2015 IBC

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- Of the 2015 I-Codes reviewed with respect to mechanical, electrical and plumbing (MEP) systems, the majority of impactful changes were observed in the International Energy Conservation Code.
- One change in the International Mechanical Code was deemed impactful from a cost perspective. This change is focused entirely supplemental equipment and controls for cooling towers.
- The majority cost-impactful changes to the International Residential Code are related to equipment specific to roof-mounted solar collectors found in Chapter 23, Section M2301 (Thermal Solar Energy Systems) of the Florida Residential Building Code.
- Overall trends in the commercial sector point towards the specification of mechanical and electrical equipment with more superior efficiency ratings, the addition of control points and sequences and additional commissioning requirements.

# NEC Changes Cost Impact Analysis

## Disclaimer - Probable Construction Costs Opinions

### Assumptions

- This Estimate is not a guarantee of Final Bid Cost or of Final Project Cost.
- This is an Opinion of Probable Cost of Mechanical, Electrical, and Piping (MEP) Systems for the proposed buildings.
- The estimate was compiled using documents provided by various sources.
- The estimate is representative of average unit pricing and labor from historical job costs of similar type, cost and labor data from Mechanical Contractors Association of America (MCAA), CostWorks 2015 Qtr. 2 (Change Date and Qtr) by R.S. Means Company Inc, National Electrical Contractors Association (NECA) and Sheet Metal Estimating by Wendes.
- The subcontractor unit rates include the subcontractor's overhead and profit, unless otherwise stated.
- The mark-ups included in the unit prices cover the cost of field overhead, home office overhead and profit, and range from 15% to 25% of the costs of a particular item.
- Since we have no control over the cost of labor, material and equipment, or the contractor's method of carrying out the work and determining the price, or over competitive bidding or market conditions, this opinion of probable construction cost provided is made on the basis of experience and qualifications. This opinion represents our best judgment as professional construction consultants with the Construction Industry. However, we cannot and do not guarantee that proposals, bids or the construction cost will not vary from the opinions of probable cost in this estimate.



# NEC Changes Cost Impact Analysis

## Disclaimer - Probable Construction Costs Opinions

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### General Assumptions:

- "Allowances" are considered to be an allotted sum of money for a particular system or scope of work for which sufficient detail is not available to determine a definitive cost.
- These cost allowances are included to project a final cost to include labor, material, equipment and any subcontractor costs.
- The owner receives the savings for any amount under the allowance and is at risk for any amount over the allowance.
- The estimate is in today's dollars, and has been adjusted to the local area.
- This estimate does not include any fees or permits.
- This estimate is intended to reflect construction costs only.
- This estimate is intended to reflect normal construction schedules only.
- Variations in material costs, labor efficiencies, wage rates, union practices, and bid climate will effect final costs.
- Workers will report to the actual job site.
- Materials delivered to the actual job site will need to be scheduled.
- No premium or overtime has been included.
- No General Construction costs have been included.
- All utilities have sufficient capacity for the added loads.

# Excerpts – NEC Changes Cost Impact Analysis

APPENDIX G - Table 7. NEC Changes Cost Impact		
CODE CHANGE #	2015 NEC CHANGE SUMMARY	ESTIMATED AMOUNT*
55	<b>110.26(C)(3)</b> Revised personnel door requirements by reducing the 1200-ampere threshold to 800 amperes.	\$400
60	<b>110.27(A)(4)</b> Revised to reflect differing elevation requirements for differing voltage thresholds.	Minimal cost impact
77	<b>210.8(A)(7)</b> Revised to require GFCI protection of 125-volt, 15- and 20-ampere receptacles installed within 6 ft. of a sink that are not covered by the kitchen countertop rule in 210.8(A)(6).	\$25
78	<b>210.8(A)(9)</b> New requirement for GFCI protection of 125-volt, 15- and 20-ampere receptacles installed within 6 ft. of the outside edge of a bathtub or shower stall.	\$25
79	<b>210.8(A)(10)</b> New requirement for GFCI protection of 125 volt, 15- and 20-ampere receptacles installed in laundry areas.	\$25
81	<b>210.8(B)(8)</b> Revised to require GFCI protection of all 125-volt, 15- and 20-ampere receptacles installed in garages located at other than dwelling units. The requirement does not apply to receptacles installed in showroom or exhibition areas.	\$25
82	<b>210.8(D)</b> New requirement for GFCI protection of outlets that supply dishwashers installed in dwelling units.	\$25
85	<b>210.12(A)</b> Revised to expand the AFCI protection requirement to kitchens and laundry areas, and to specify that AFCI protection is required for branch circuits supplying outlets and devices.	\$200
88	<b>210.12(C)</b> New requirement for AFCI protection of outlets supplied by 120 volt, 15- and 20-ampere branch circuits that are installed in certain rooms of dormitories.	\$40
89	<b>210.13</b> New requirement for ground-fault protection of equipment where a branch-circuit disconnecting means is rated 1000 amperes or more and is supplied from a solidly-grounded, wye-connected system operating over 150 volts to ground, but not more than 600 volts phase to phase.	\$3,000

\*For prescriptive Code changes only.

# Excerpts – NEC Changes Cost Impact Analysis

APPENDIX G - Table 7. NEC Changes Cost Impact		
CODE CHANGE #	2015 NEC CHANGE SUMMARY	ESTIMATED AMOUNT*
101	<b>210.52(G)(1)</b> Revised to require at least one receptacle outlet for each car parking space in a dwelling unit garage and to restrict the branch circuit supplying garage receptacle outlets from supplying outlets located outside of the garage.	\$50
104	<b>210.64</b> New requirement specifying the installation of at least one 125-volt, 15- or 20-ampere receptacle outlet within 50 ft. of electrical service equipment for all buildings other than one- and two-family dwelling units.	\$50
109	<b>220.12 Exception</b> New exception to permit calculation of the general lighting load to be performed per locally adopted energy codes, provided the feeder demand factors permitted by the <i>Code</i> are not applied to the general lighting load. The general lighting load is required to be continually monitored by equipment with an alerting feature that activates when the load determined through energy code calculation is exceeded.	Would lead to smaller electrical systems, but the cost of monitoring would likely outweigh any cost savings.
110	<b>220.14(B)</b> Revised the title of this section to identify that this load calculation is also permitted to be used to determine the load of household ranges used in instructional programs as specified in Note 5 to Table 220.55.	\$750
125	<b>225.36</b> Revised by requiring that the feeder or branch-circuit disconnecting means be suitable for use as service equipment only where the feeder grounded conductor is also used as the return path for ground-fault current per 250.32(B)(1). The exception permitting a three- or four-way snap switch to be used as a disconnecting means for an outside branch circuit or feeder has been deleted.	Service entrance equipment would generally not be required for out buildings and structures. \$50

\*For prescriptive Code changes only.

# Excerpts – NEC Changes Cost Impact Analysis

APPENDIX G - Table 7. NEC Changes Cost Impact		
CODE CHANGE #	2015 NEC CHANGE SUMMARY	ESTIMATED AMOUNT*
137	<b>230.6(5)</b> Revised to restrict service masts running through the eave of a building to rigid metal conduit and intermediate metal conduit.	Although a potential cost increase, not aware of any utility companies that do not already require this.
146	<b>230.44</b> Revised to provide specific intervals for marking of cable trays containing service-entrance conductors.	Minimal
172	<b>240.87</b> Revised by limiting the application of this requirement to circuit breakers that are rated or can be adjusted to 1200 amperes or more. Also revised to add more methods that can be used to provide arc flash mitigation.	\$5,000. Broadens the range of installation that require arc energy reduction strategy.
231	<b>250.167</b> New section that requires ground fault detection for dc systems.	\$500.00
319	<b>330.30(B)</b> New permissive provision for 250 kcmil and larger cable constructions to be supported at intervals as great as 10 feet in vertical installations.	Minimal
396	<b>406.3(E)</b> New requirement for field marking of 125 volt, 15- and 20-ampere receptacles that are controlled by an energy management system, timer, or some other automatic means. This marking must be made using the standard symbol shown in Figure 406.3(E).	\$5

\*For prescriptive Code changes only.

# Excerpts – NEC Changes Cost Impact Analysis

APPENDIX G - Table 7. NEC Changes Cost Impact		
CODE CHANGE #	2015 NEC CHANGE SUMMARY	ESTIMATED AMOUNT*
511	<b>490.48</b> New section that includes requirements for substation design by a qualified licensed professional, and also includes engineer, documentation, and diagram requirements.	\$1,200. Cost would vary with scope.
641	<b>517.30(G)</b> New requirement for overcurrent protective devices serving the essential electrical system to be selectively coordinated for the period of time that a fault's duration extends beyond 0.1 second. Two exceptions to the rule address the arrangement between transformer primary and secondary protective devices and overcurrent protective devices of the same ampere rating connected in series.	\$3,000
685	<b>551.41(B)(4)</b> New requirement for at least one receptacle for rooftop decks that is accessible from inside the RV.	\$100
790	<b>645.27</b> New requirement covering selective coordination of overcurrent devices protecting circuits supplying critical operations data systems.	\$500.00
840	<b>690.11</b> Revised to expand the series arc fault protection requirement to conductors installed indoors and outdoors.	\$250
847	<b>690.15(C)</b> New provision for installation of a disconnecting means within 6 feet of dc combiners mounted on rooftops.	\$500, Price will vary greatly with scope of project
921	<b>700.8</b> New requirement covering installation of surge protection devices (SPDs) at panelboards and switchboards supplied by emergency systems.	\$500
958	<b>705.12(D)(6)</b> New requirement for AFCI protection of exposed inverter output circuit wiring operating at 240 volts with a circuit current rating of 30 amperes or less.	\$100

\*For prescriptive Code changes only.

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**QUESTIONS ?**