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Evaluation of the Cost Impact of 2015 IBC Prescriptive Code Changes

R. Raymond Issa, PhD, JD, PE, F ASCE, API

Holland Professor & Director

Center for Advanced Construction Information Modeling

Rinker School of Construction Management

University of Florida

Research Team

- R. Raymond Issa, Ph.D. Civil Eng., J.D., P.E., F. ASCE, raymond-issa@ufl.edu), (352) 273-1152
- Russel Walters, Ph.D. Electrical Eng., rwalters@ufl.edu, (352) 273-1173
- John Chyz, P.E., Affiliated Engineers, Inc (AEI), jchyz@aeieng.com, (352) 376-5500
- Mark Aaby, P.E., Fire Protection Engineer, Koffel Assoc., maaby@koffel.com, (410) 750-2246
- Kristin Steranka, Fire Protection Engineer, Koffel Assoc., ksteranka@koffel.com, (410) 750-2246

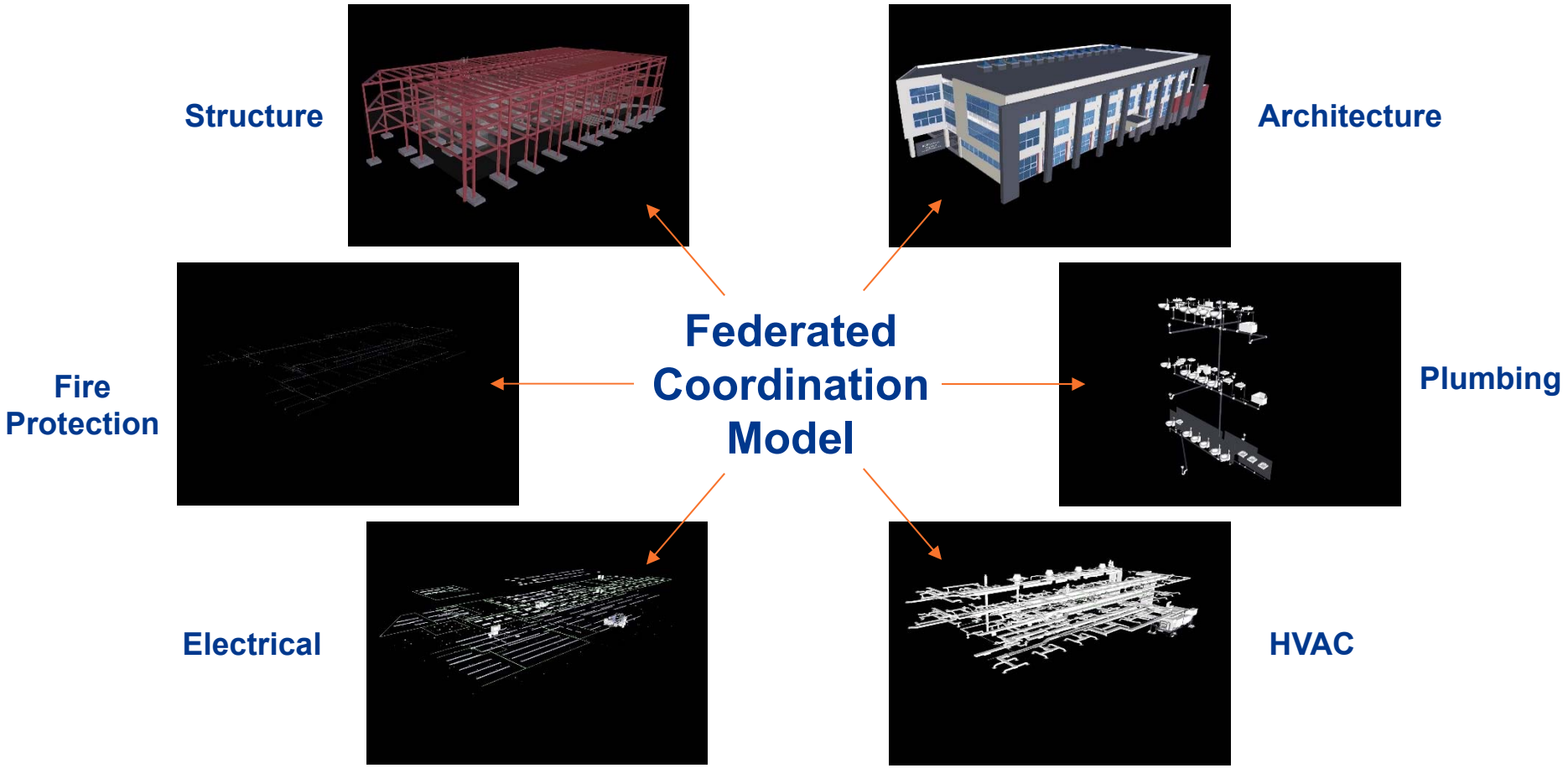
BIM: What is Building Information Modeling?

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.

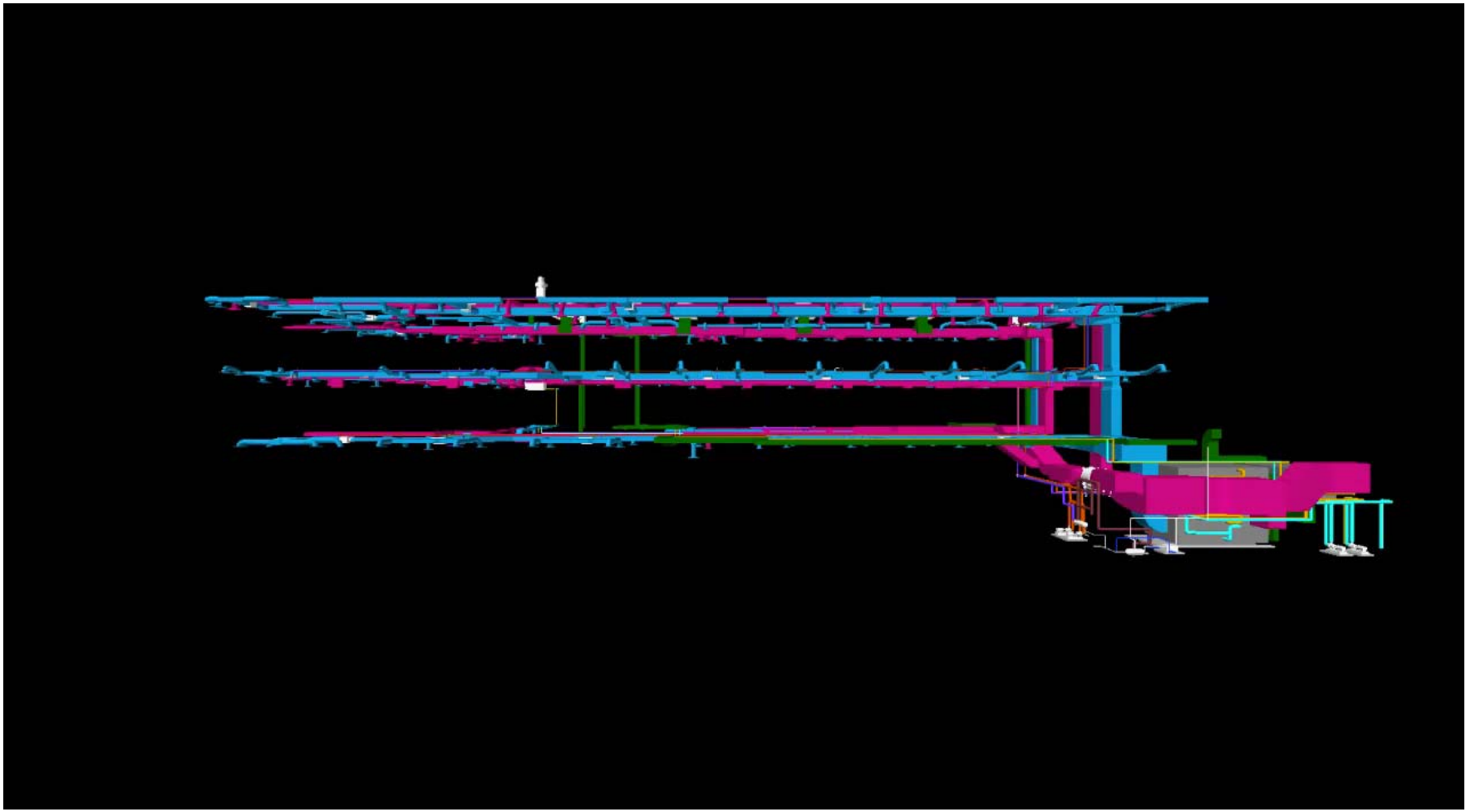
BIM: Benefits of BIM?

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



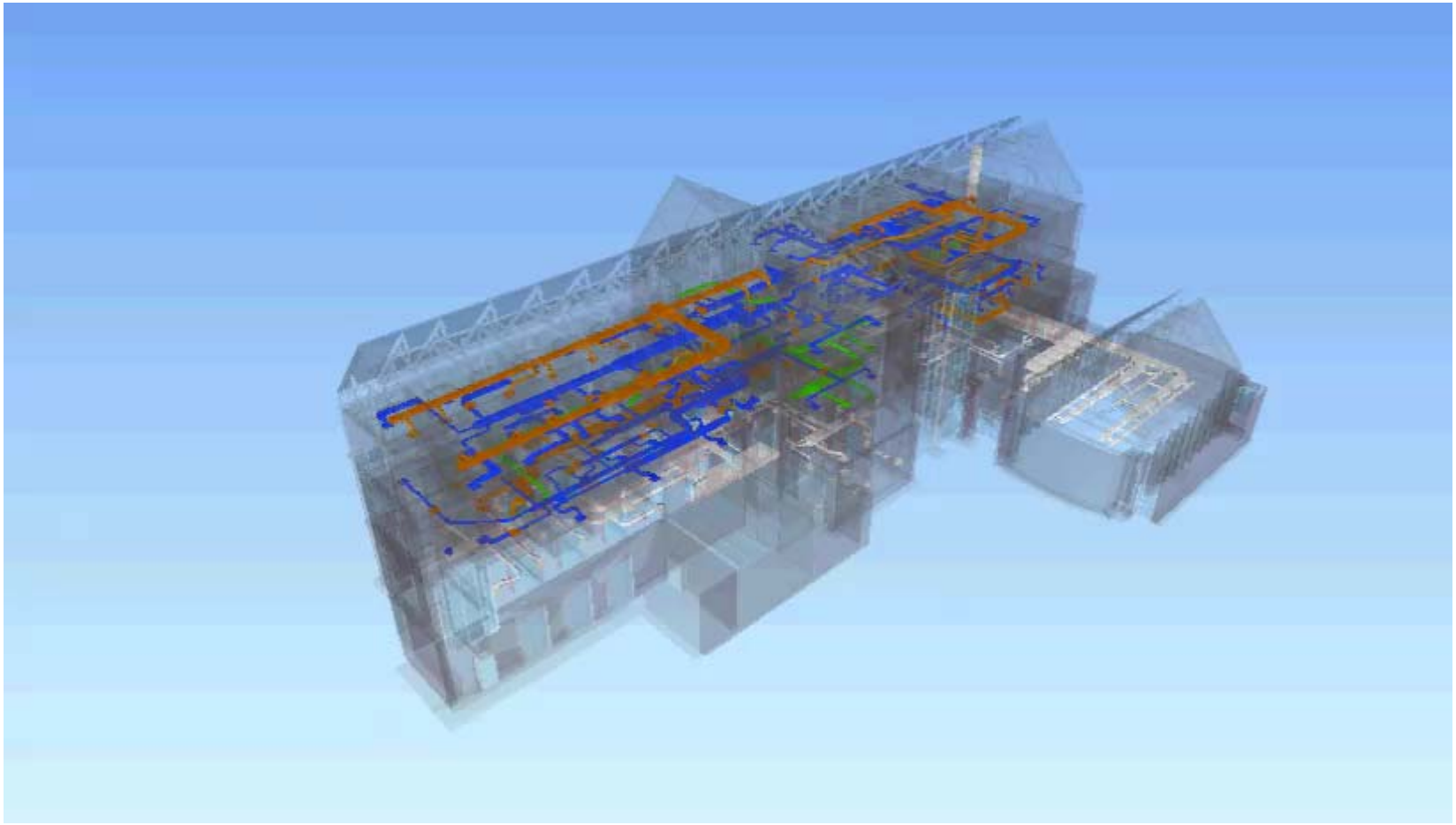
BIM: HVAC Model of Rinker Hall



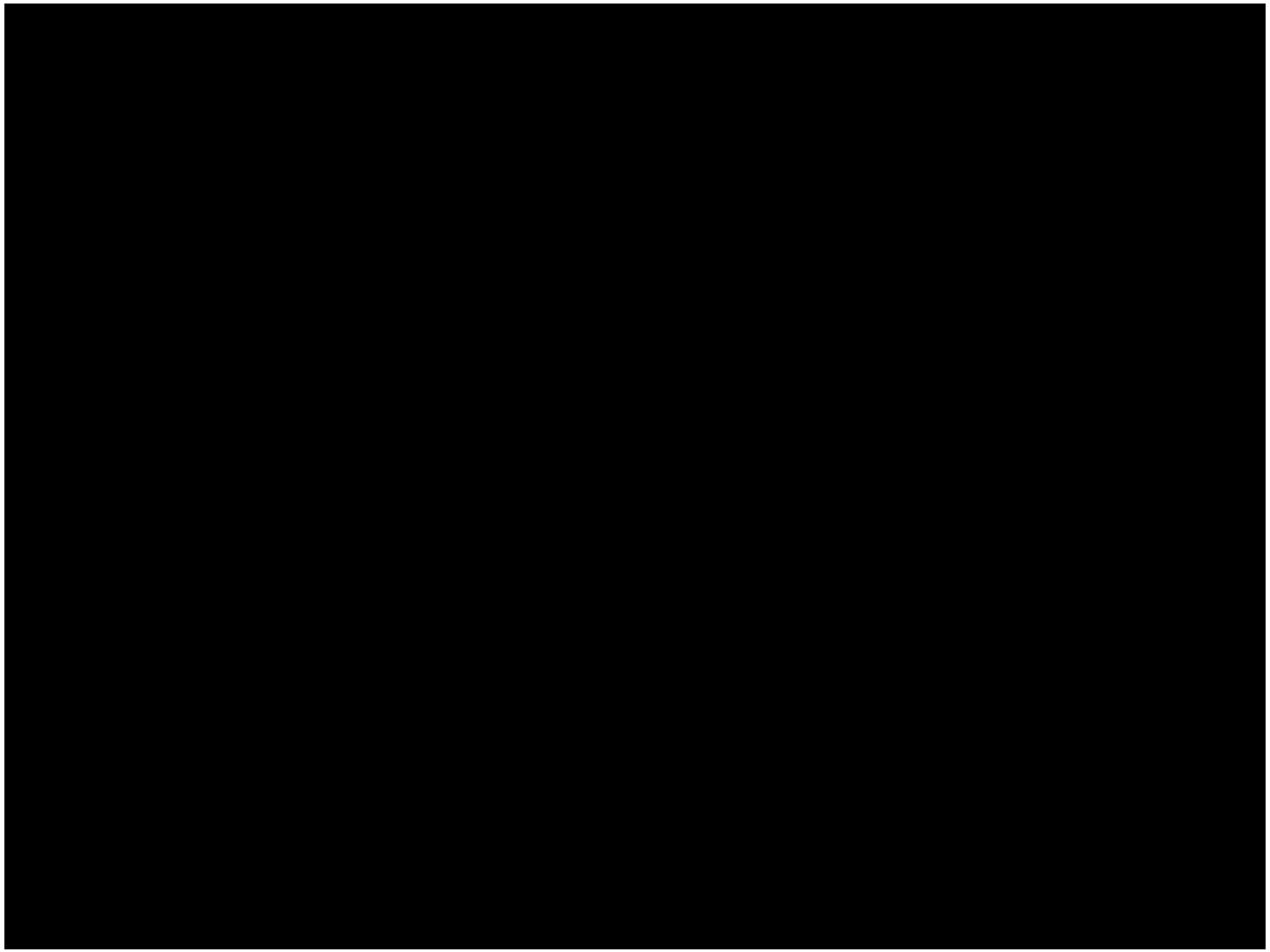
BIM: Building Information Modeling

- Federated Multi-Disciplinary Model

BIM: Embedded MEP Model of Gerson Hall

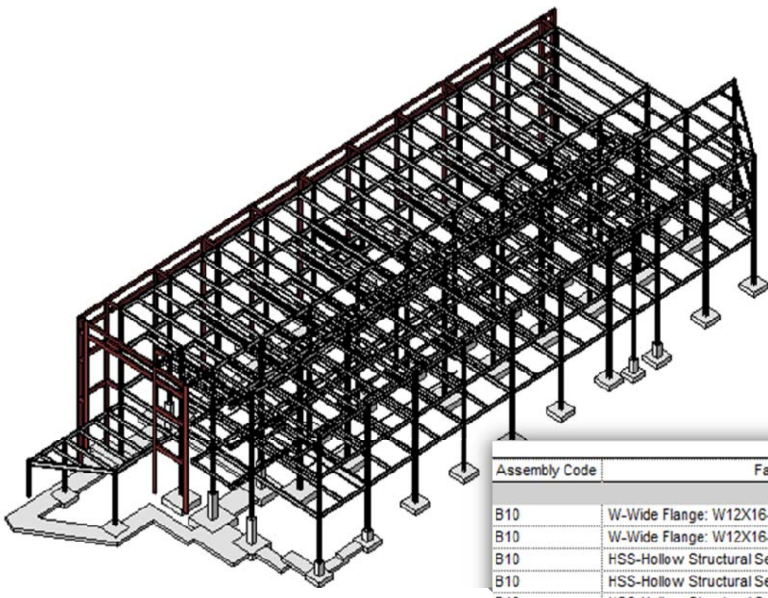


BIM: Ramp Construction Simulation



BIM: Quantity Surveys

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



F7-84"x84"x18"					
A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
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A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
A101010	Footing-Rectangular	F7-84"x84"x18"	6' - 0"	6' - 0"	1
A101010	Footing-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
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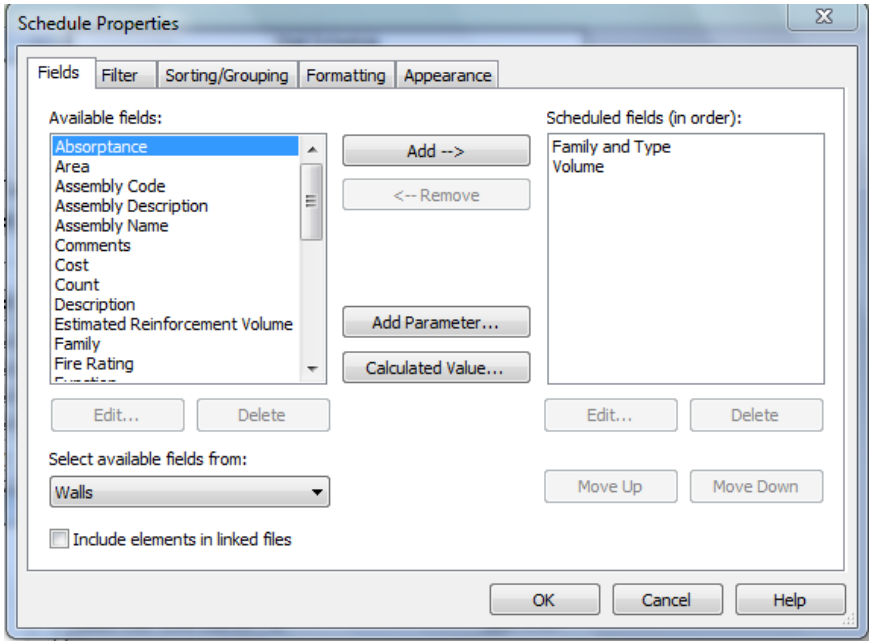
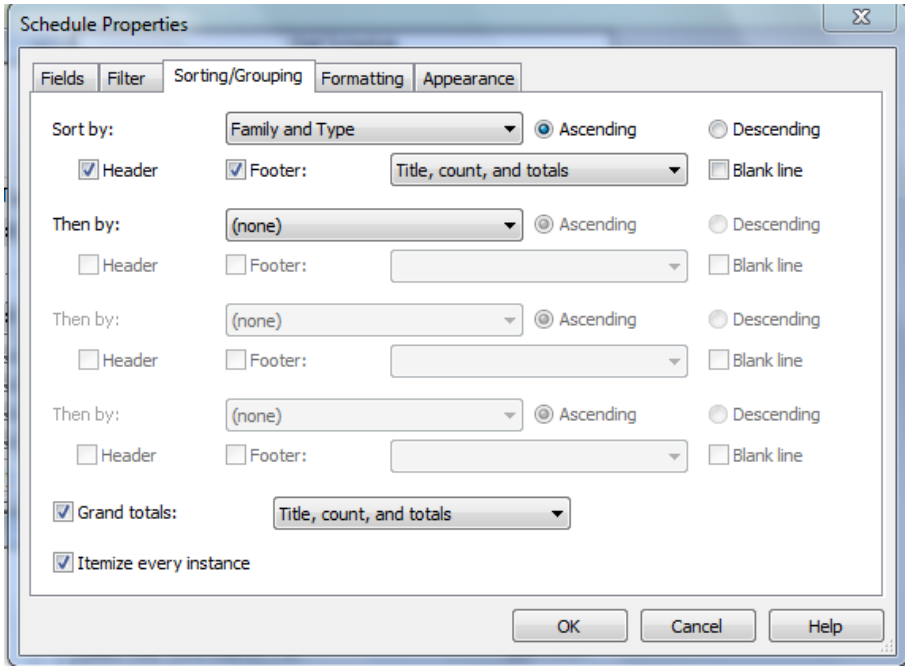
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	18' - 8"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	9' - 10"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	11' - 7"	10.00
B10	HSS-Hollow Structural Section: HSS12X8X.3125-RINKER	1	26' - 11"	10.00

BIM: Quantity Surveys

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



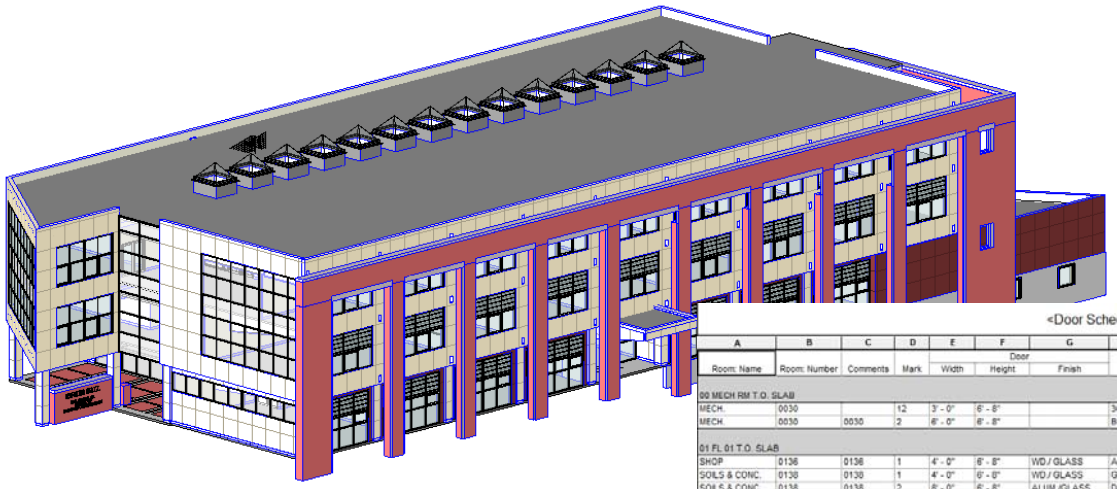


BIM: Quantity Surveys

- 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	BIM LAB	845 SF						



<Door Schedule>

A	B	C	D	E	F	G	H	I	J	K	L	M
				Door				Frame	Fire			
Room: Name	Room: Number	Comments	Mark	Width	Height	Finish	Type	Type	Rating	Hardware	Cost	Level
00 MECH RM T.O. SLAB												
MECH.	0030		12	3' - 0"	6' - 8"		36" x 80"					00 MECH RM T.O.
MECH.	0030	0030	2	6' - 0"	8' - 8"		B		45			00 MECH RM T.O.
01 FL 01 T.O. SLAB												
SHOP	0136	0136	1	4' - 0"	8' - 8"	WD./ GLASS	A	H.M./PTD.	60 min	9		01 FL 01 T.O. SLA
SOILS & CONC.	0138	0138	1	4' - 0"	6' - 8"	WD./ GLASS	G	H.M./PTD.		4		01 FL 01 T.O. SLA
SOILS & CONC.	0138	0138	2	8' - 0"	6' - 8"	ALUM./GLASS	D-Doule	ALUM.		4		01 FL 01 T.O. SLA
STORAGE	0140A	140	2	8' - 0"	6' - 8"	ALUM./GLASS	D-Doule	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	C199D	143	1	3' - 0"	6' - 8"	ALUM./GLASS	C	ALUM.		5		01 FL 01 T.O. SLA
MECH. ROOM	0146A	0146A	1	3' - 0"	6' - 8"	H.M./PTD.	E-FIRE RATED	H.M./PTD.	45 min	4		01 FL 01 T.O. SLA
CORRIDOR	C199D	C196A	4	3' - 0"	6' - 9 11/16"	ALUM./GLASS	D-Left	ALUM.		1		01 FL 01 T.O. SLA
CORRIDOR	C199D	C196A	5	6' - 1"	6' - 9 11/16"	ALUM./GLASS	D-Doule	ALUM.		3		01 FL 01 T.O. SLA
CORRIDOR	C199D	C196A	6	3' - 0"	6' - 9 11/16"	ALUM./GLASS	D-Right	ALUM.		2		01 FL 01 T.O. SLA
MEDIUM CLASS	0106	C199B	1	6' - 0"	8' - 8"	WD./ GLASS	K	H.M./PTD.		10		01 FL 01 T.O. SLA
LARGE CLASS	0110	C199B	2	6' - 0"	8' - 8"	WD./ GLASS	K	H.M./PTD.		10		01 FL 01 T.O. SLA
ELEC.	0110A	C199B	3	6' - 0"	6' - 8"	H.M./PTD.	B	H.M./PTD.	45	21		01 FL 01 T.O. SLA
ELEC.	0110A	C199B	4	6' - 0"	6' - 8"	H.M./PTD.	B	H.M./PTD.	45	12		01 FL 01 T.O. SLA
LARGE CLASS	0110	C199C	1	3' - 0"	8' - 8"	H.M./PTD.	A - 6'8x3'0	H.M./PTD.	45 min	13		01 FL 01 T.O. SLA
WOMEN	0146	C199D	1	3' - 0"	6' - 8"	H.M./PTD.	E	H.M./PTD.		14		01 FL 01 T.O. SLA
MEN	0145	C199D	2	3' - 0"	6' - 8"	H.M./PTD.	E	H.M./PTD.		14		01 FL 01 T.O. SLA
STRUCTURES S	0140	C199D	3	3' - 0"	6' - 8"	WD./ GLASS	G- 6'8x3'0	H.M./PTD.		15		01 FL 01 T.O. SLA
STUDENT LOUN	0115	C199D	4	3' - 0"	6' - 8"	WD./ GLASS	G- 6'8x3'0	H.M./PTD.		15		01 FL 01 T.O. SLA
M.E.P STUDIO	0125	C199D	5	3' - 0"	6' - 8"	WD./ GLASS	G- 6'8x3'0	H.M./PTD.		15		01 FL 01 T.O. SLA

ISSUES

- 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

- **1. Review/analyze the 2015 I-Code changes to the 2012 I-Code to identity 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, 1st	Yes	Yes
8 ft. Ceilings, 2nd	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 IMC

- 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.

2015 IMC 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.

2015 IMC Changes Cost Impact Analysis
Disclaimer - Probable Construction Costs Opinions

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 – 2015 IMC Changes Cost Impact Analysis

APPENDIX D - Table 4. 2015 IMC Changes Cost Impact		
CODE CHANGE #	**2015 IPC CHANGE SUMMARY**	**ESTIMATED AMOUNT***
M165-12	**Section(s): 908.8 (New), Chapter 15** **908.8 Cooling Towers.** Cooling towers greater than 150 tons in capacity shall comply with Sections 908.8.1 through 908.8.4. 908.8.1 Conductivity or Flow-based Control. Cooling towers shall include of controls that maximize the cycles of concentration based on local water quality conditions. Such controls shall automate system bleed and chemical feed based on conductivity or in proportion to metered makeup volume, metered bleed volume, or bleed time. 908.8.2 Flow Meter. A water meter or sub-meter shall be installed to measure the volume of makeup water entering the cooling tower. Where both potable and non-potable water are supplied to the tower, a meter or sub-meter shall be installed to measure each source separately. 908.8.3 Overflow Alarm. Cooling towers shall include of an overflow alarm to prevent overflow of the sump in case of makeup water valve failure. Such overflow alarm shall send an audible signal or provide an alert by means of the Building Management System to the tower operator in case of sump overflow. 908.8.4 Drift Eliminators. Cooling towers shall be equipped with drift eliminators that achieve drift reduction to 0.002 percent of the circulated water volume. Drift eliminators shall be tested using the Isokinetic Drift Measurement Test Cost for Water Cooling Tower – ATC – 140" testing code from the Cooling Technology Institute.	1% to 2% of Equipment Cost Increase

***For prescriptive Code changes only.**

Excerpts – 2015 IRC MEP Changes Cost Impact Analysis

APPENDIX E - Table 5. 2015 IRC MEP Changes Cost Impact		
CODE CHANGE #	**2015 IRC MEP CHANGE SUMMARY**	**ESTIMATED AMOUNT***
RM21-13	**Section(s): M1411.3.3 (New)** **M1411.3.3 Drain Line Maintenance.** Condensate drain lines shall be configured to permit the clearing of blockages and performance of maintenance without requiring the drain line to be cut.	$15/unit
RM77-13	**Section(s): M2301.2.2 (New), M2301.2.2, M2301.2.2.2 (New), Chapter 44** **M2301.2.2 Collectors and panels.** Solar collectors and panels shall comply with Sections M2301.2.2.1 and M2301.2.2.2. **M2301.2.2.1 ~~M2301.2.2~~ Roof-mounted collectors.** The roof shall be constructed to support the loads imposed by roof-mounted solar collectors. Roof-mounted solar collectors that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9 of this code. Where mounted on or above the roof coverings, the collectors and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction. M2301.2.2.2 Collector sensors. Collector sensor installation, sensor location and the protection of exposed sensor wires from ultraviolet light shall be in accordance with SRCC 300.	
RM82-13	**Section(s): R202, M2301.2.3, Chapter 44** **M2301.2.3 Relief valves and system components.** System components containing fluids shall be protected with temperature and pressure ~~and temperature~~ relief valves or pressure relief valves. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device. Direct systems and the potable water portion of indirect systems shall be equipped with a relief valve in accordance with Section P2803, For indirect systems, pressure relief valves in solar loops shall comply with SRCC 300. System components shall have a working pressure rating of not less than the setting of the pressure relief device. Add new standard to **Chapter 44** as follows: SRCC 300-13 Standard 300 For Solar Water Heating Systems	Negligible cost as change should reflect an update to the design and contract documents

***For prescriptive Code changes only.**

Excerpts – 2015 IRC MEP Changes Cost Impact Analysis

APPENDIX E - Table 5. 2015 IRC MEP Changes Cost Impact

CODE CHANGE #	2015 IRC MEP CHANGE SUMMARY	ESTIMATED AMOUNT*
RM84-13	**Section(s): M2301.2.5 (New)** **M2301.2.5 Piping insulation.** Piping shall be insulated in accordance with the requirements of Chapter 11. Exterior insulation shall be protected from ultraviolet degradation. The entire solar loop shall be insulated. Where split-style insulation is used, the seam shall be sealed. Fittings shall be fully insulated.	Negligible cost as change should reflect an update to the design and contract documents
RM86-13	**Section(s): M2301.2.6 (New), Chapter 44** **M2301.2.6 Storage tank sensors.** Storage tank sensors shall comply with SRCC 300.	Negligible cost as change should reflect an update to the design and contract documents
RM87-13	**Section(s): M2301.2.6 (New), M2301.2.7 (New)** **M2301.2.6 Mixing valves.** Where heated water is discharged from a solar thermal system to a hot water distribution system, a thermostatic mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140o F. Solar thermal systems supplying hot water for both space heating and domestic uses shall comply with Section P2802.2. A temperature indicating device shall be installed to indicate the temperature of the water discharged from the outlet of the mixing valve. The thermostatic mixing valve required by this section shall not be a substitute for water temperature limiting devices required by Chapter 27 for specific fixtures. **M2301.2.7 Isolation valves.** Isolation valves shall be provided on the cold water feed to the water heater. Isolation valves and associated piping shall be provided to bypass solar storage tanks where the system contains multiple storage tanks. **P2802.1 Water temperature control.** Where heated water is discharged from a solar thermal system to a hot water distribution system, a thermostatic mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140o F. Solar thermal systems supplying hot water for both space heating and domestic uses shall comply with Section P2802.2. A temperature indicating device shall be installed to indicate the temperature of the water discharged from the outlet of the mixing valve. The thermostatic mixing valve required by this section shall not be a substitute for water temperature limiting devices required by Chapter 27 for specific fixtures. P2802.2 Isolation valves. Isolation valves in accordance with P2903.9.2 shall be provided on the cold water feed to the water heater. Isolation valves and associated piping shall be provided to bypass solar storage tanks where the system contains multiple storage tanks.	Negligible cost as change should reflect an update to the design and contract documents

*For prescriptive Code changes only.

Excerpts – 2015 IRC MEP Changes Cost Impact Analysis

APPENDIX E - Table 5. 2015 IRC MEP Changes Cost Impact

CODE CHANGE #	2015 IRC MEP CHANGE SUMMARY	ESTIMATED AMOUNT*
RM88-13	**Section(s): M2301.2.8 (New), M2301.2.9 (New), M2301.9.1, M2301.2.9.2 (New), Chapter 44** **M2301.2.8 Description and warning labels.** Solar thermal systems shall comply with description label and warning label requirements of Section M2301.2.9.2 and SRCC 300. M2301.2.9 Solar loop. Solar loops shall be in accordance with Sections M2301.2.8.1 and M2301.2.8.2. M2301.9.1 ~~M2301.2.8~~ Solar loop isolation. Valves shall be installed to allow the solar collectors to be isolated from the remainder of the system**M2301.2.9.2 Drain and fill valve labels and caps.** Drain and fill valves shall be labeled with a description and warning that identifies the fluid in the solar loop and a warning that the fluid might be discharged at high temperature and pressure. Drain caps shall be installed at drain and fill valves. Add new standard to Chapter 44 as follows: SRCC 300-13 Standard 300 For Solar Water Heating Systems	Negligible cost as change should reflect an update to the design and contract documents
RM90-13	**Section(s): Section M2301.4, Chapter 44** M2301.4 Heat transfer gasses or liquids and heat exchangers. ~~Prohibited heat transfer fluids~~. Flammable gases and liquids shall not be used as heat transfer fluids. Heat transfer gasses and liquids shall be rated to withstand the system's maximum design temperature under operating conditions without degradation. Heat exchangers used in solar thermal systems shall comply with Section P2902.5.2 and SRCC 300.	Negligible cost as change should reflect an update to the design and contract documents
RM93-13	**Section(s): M2301.6 (New), M2301.6.1 (New), M2301.6.2 (New), P2902.5.5** M2301.6 Solar systems for heating potable water. Where a solar energy system heats potable water to supply a potable hot water distribution system, the solar energy system shall be in accordance with Sections M2301.6.1, M2301.6.2 and P2902.5.5. M2301.6.1 Indirect systems. Heat exchangers that are components of indirect heating systems shall comply with Section P2902.5.2. M2301.6.2 Direct systems. Where potable water is directly heated, the pipe, fittings and valves between the solar collectors and the hot water storage tanks shall comply with NSF 61. Revise as follows: P2902.5.5 Solar systems. ~~The potable water supply to a solar system shall be equipped with a backflow preventer with intermediate atmospheric vent complying with ASSE 1012 or a reduced pressure principle backflow preventer complying with ASSE 1013. Where chemicals are used, the potable water supply shall be protected by a reduced pressure principle backflow preventer.~~ Where a potable water supply is connected to the solar collector circulation loop piping of an indirect solar water heating system and chemicals are not used in the circulation loop piping, a backflow preventer in accordance with ASSE 1012 shall be installed between the potable water system and the circulation loop piping. Where chemicals are used in the solar collector circulation loop piping, such backflow preventer shall be in accordance with ASSE 1013.	Negligible cost as change should reflect an update to the design and contract documents

*For prescriptive Code changes only.

QUESTIONS ?