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Development of a Texas Building Registry

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ABSTRACT

The Texas Building Registry (TBR or Registry) provides data collection, storage, and analysis of above-code residential housing construction in Texas. The original system was developed to support the Texas Emissions Reduction Plan (TERP). Since 2005, the Energy Systems Laboratory (The Laboratory) has provided web-based, above code energy efficiency calculators for public use. The Registry can accept single entry and batch loading of data describing Energy Star™ homes, low-income weatherization programs, or data from municipal code enforcement systems. The Registry is independent of, and respectful of, other rating systems used by partners, thus it can accept data for homes measured against Energy Star, IECC 2000/2001, 2006, 2009, and specially amended Codes. Reports can be given summarized geographically against weather zones, county or cities, and even displayed on a map (i.e., thematic mapping). Additional reports on building characteristics can be analyzed and reported such as: HVAC tonnage per sq. ft; or average SHGC. Data provided by partners is kept secure database server located at the Texas A&M University. Individual results from the Registry will not be displayed to further respect the privacy of individuals who have provided the data.

BACKGROUND

Since 2001, Texas has been proactive in initiating clean air and energy efficiency-in-buildings policies. The Texas Emissions Reduction Plan (TERP) Legislation (SB 5, 77TH Leg., 2001), mandates state-wide adoption of energy codes, creates a 5% annual energy savings goal for public facilities in affected counties through 2007 and provides approximately $150 million in cash incentives for clean diesel emissions grants and energy research among other measures. Texas was the first state in the nation to create emissions reduction credits for energy efficiency and renewable energy through the State Implementation Plan under the Federal Clean Air Act.

In 2008, the 81st Texas Legislature amended the Texas Administrative Code (TAC .§388.008 2009) to develop a Registry of Above-Code homes. The Laboratory built the first version of the Registry in 2009. This preliminary version allowed The Laboratory to provide basic metrics on usage of the Laboratory's above code calculators, *IC3*[1] and *TCV*[2]. By running reports against the calculator's databases, The Laboratory could determine calculator usage by month for Texas' Cities and Counties. These reports allowed a better understanding of how builders were adopting the calculators across the State so the Laboratory could improve the calculators.

Residential energy standards help create more energy-efficient homes and thus reduce air pollution from electricity generation. Texas programs have partially transformed the housing market in Dallas/Fort Worth and Houston with 30,000 Energy Star homes (approximately 27 %) in 2006, which have reduced emissions from

[1] International Code Compliance Calculator, a web based, above code calculator for single family, detached, new construction in Texas.

[2] Texas Climate Vision, a web based, above code calculator for single family, detached, new construction in Austin Energy's service area.

building energy-efficient homes, and have created new manufacturing jobs for energy-efficient equipment and windows. In 2008, the figures were 32,000 units or 41% Texas market penetration (US Department of Energy 2009), just as the recession was taking hold.

METHODOLOGY

Each year the Registry adds data and reporting capability.

REGISTRY (2009 EDITION)

The 2009 edition allows The Laboratory to provide basic metrics on usage and overall energy consumption of the proposed houses from the laboratory's above code calculators, *IC3* and *TCV*.

As illustrated below and a "*Report on the Development of the Format for a Texas Residential Registry* (Gilman, et al. 2008), the underlying database was optimized for supporting the *IC3* and *TCV* calculators and therefore needed a transformation to allow for seamless reporting. Consequently, The Laboratory has been steadily adding reporting capability and has been making software changes to reflect the new reporting requirements and analysis capabilities.

The underlying technology of the *IC3* and *TCV* calculators was Microsoft SQL Server 2005[3]. This product offered reporting capabilities through various tools.

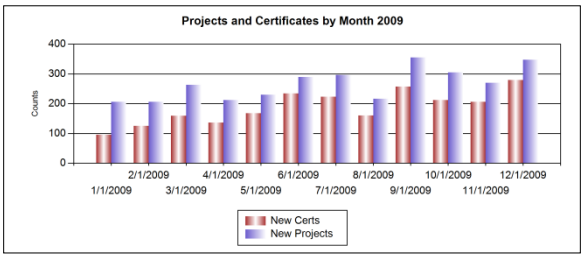

Figure 1: *IC3* 2009 Certificates and Projects

Figure 1 shows the Projects and Certificates issued each month since January 2009. A Project is a house plan, Certificates are printed reports given to the building official - assuming that the house is at or above code. In 2009, some users entered a basic floor plan and re-cycled it to generate more certificates. Figure 1 shows that more projects were entered (and presumably did not pass) than certificates created.

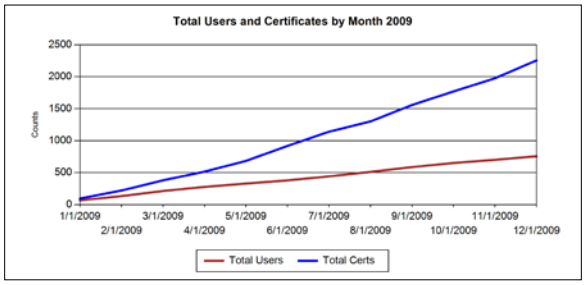

Figure 2: *IC3* 2009 Users vs. Certificates

Figure 2 shows the cumulative Users and Certificates since January 2009. The divergence between the two lines emphasizes the difference between the projects completed and certificates issued.

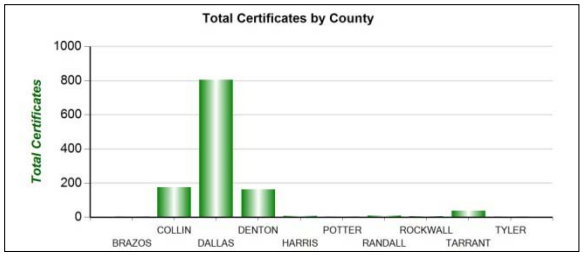

Figure 3: *IC3* 2009 Certificates - Top 10 Counties

Figure 3 shows that the earliest adopter of the *IC3* software was the North Central Texas Council of Governments (NCTCOG) area, specifically, users building in Dallas, Collin, Denton, and Tarrant Counties.

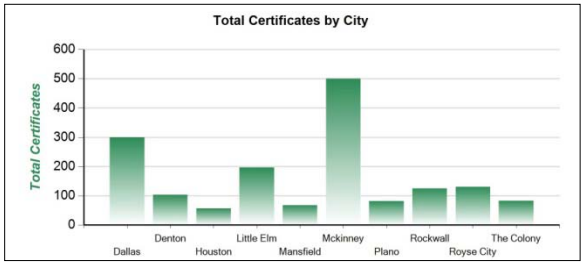

Figure 4: *IC3* 2009 Certificates - Top Ten Cities

Figure 4 shows the certifications issued by city (excluding Austin). Figure 4 shows that the City of McKinney leads the way with 500 certificates, followed by the City of Dallas, then

[3] The system is being updated to SQL Server 2008 R2 in the Fall of 2010.

Little Elm, and the other cities located in the NCTCOG area.

Since the City of Austin and much of Travis County use the *TCV* software, their usage is presented in Figure 5, below.

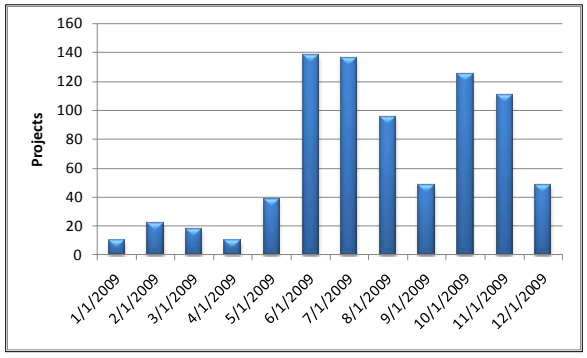

Figure 5: *TCV* 2009 Annual Energy Reports

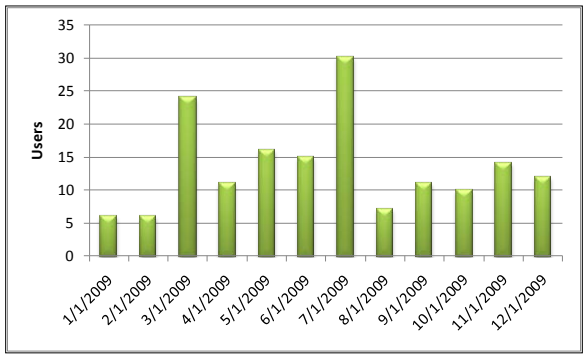

Figure 6: *TCV* 2009 New User Counts

Figure 6 shows the new users counts from the *TCV* software. The City of Austin conducted beta testing in March 2009, training sessions in the summer of 2009 and then went live with version 1.1 of the *TCV* software in July of 2009. The *TCV* software also has the capability of capturing "as built" and the results of third party testing of the homes.

REGISTRY (2010 EDITION)

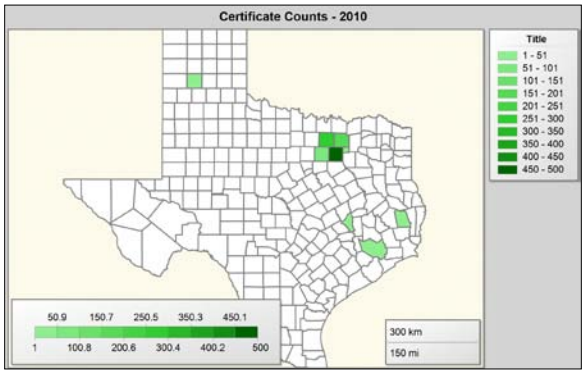

Figure 7: *IC3* 2010 Year to Date Certificate Map

The current version of the Registry is part of a broader TERP Data Repository that also contains NOAA weather data, data from building sensors, a solar test bench data, and utility bills. This newer version will have the capability to perform weather normalization of utility bill data as well as report in terms of both energy and emissions reductions.

NOAA weather data is being automatically collected for all Texas locations going back to the year 2000. Server based procedures are being developed based on Baltazar's work (Baltazar and Claridge 2002) to condition the data and flag data that requires human intervention, filling, or interpolation.

Utility bill analysis is a key part of the Laboratory's Continuous Commissioning® [4] services. Several database systems have been built to facilitate analysis of utility bill data from a variety of building types. For example, the Laboratory's original *eCalc* (Gilman, Don; Haberl, Jeff; Culp, Charles; Marshall, Kyle; Yazdani, Bahman; Liu, Zi 2004) also provided utility bill analysis and weather normalization using ASHRAE's Inverse Model Tool Kit [5]. The Laboratory will leverage this knowledge to allow

[4] Continious Commissioning® is a Service Mark of the Energy Systems Laboratory and Texas A&M University.

[5] ASHRAE's Inverse Model Toolkit (Kissock, Haberl and Claridge 2002) (IMT) a software that uses linear and change-point linear algorithims. IMT was funded under ASHRAE Project RP-1050.

the Registry to analyze electric, natural gas and water utility billing data.

Avg User/Avg Code expressed in MMBtu

	2009.10			2009.11			2009.12			2009 Q4 Averages		
	Avg User	Avg Code	% Above	Avg User	Avg Code	% Above	Avg User	Avg Code	% Above	Avg User	Avg Code	% Above
ORANGE	41.7	53.8	22.5				67.5	91.6	26.3	54.6	72.7	24.4
COMAL	63.6	76.6	17.0							63.6	76.6	17.0
SAN PATRICIO							115.6	138.3	16.4	115.6	138.3	16.4
LUBBOCK							111.5	132.6	15.9	111.5	132.6	15.9
ELLIS							46.1	54.7	15.7	46.1	54.7	15.7
KING	90.3	108.3	16.6	103.2	121.1	14.8				96.8	114.7	15.7
HUTCHINSON	81.5	95.9	15.0							81.5	95.9	15.0
IRION				83.7	97.2	13.9				83.7	97.2	13.9
WILSON	97.2	111.1	12.5							97.2	111.1	12.5
TYLER	63.0	74.9	15.9	74.5	80.5	7.5				68.8	77.7	11.7
HOOD	201.3	234.2	14.1				390.0	429.1	9.1	295.6	331.7	11.6
KLEBERG							70.1	79.2	11.6	70.1	79.2	11.6

Figure 8: 2009 4th Qtr – Energy Prototype Report

Figure 8 shows an additional report is being developed that will give average MMBtu for both the as designed and code versions of the home and % average above code by County.

During 2010, the Laboratory is upgrading the IT infrastructure. The servers supporting TERP are being replaced with modern systems that are ten times more powerful and use 1/3 less electricity than the systems they replace. This new hardware will allow the Laboratory to update key reports automatically each day. This functionality is provided by the new Microsoft *SQL Server 2008 R2* software.

REGISTRY ORGANIZATION

INTENDED DATA FLOWS

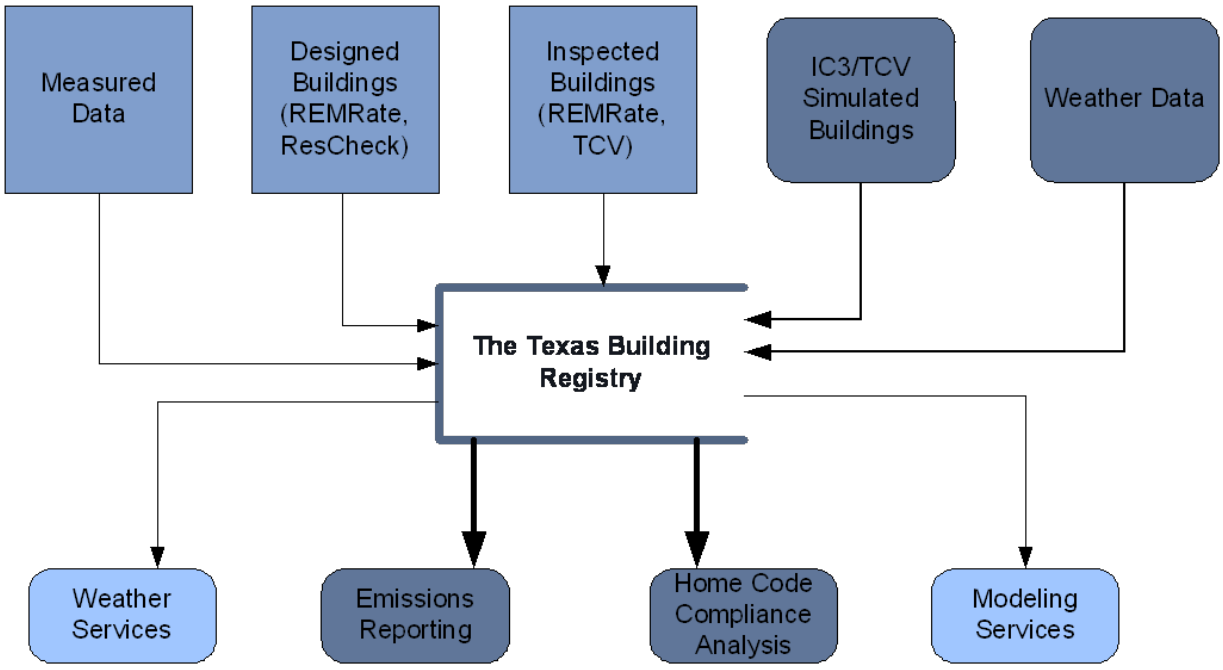

Figure 9: High Level View of Data Flows

Figure 10 shows a very high-level view of the major functional blocks of the Registry. The top level push data into the system and the bottom level draw data out. Data cleaning, flagging, and

quality assurance routines are not separated in this diagram. Dark blue coloring indicates functionality that is in place, light blue indicates functionality being actively assembled. The following sections describe several of the functional blocks of Figure 10.

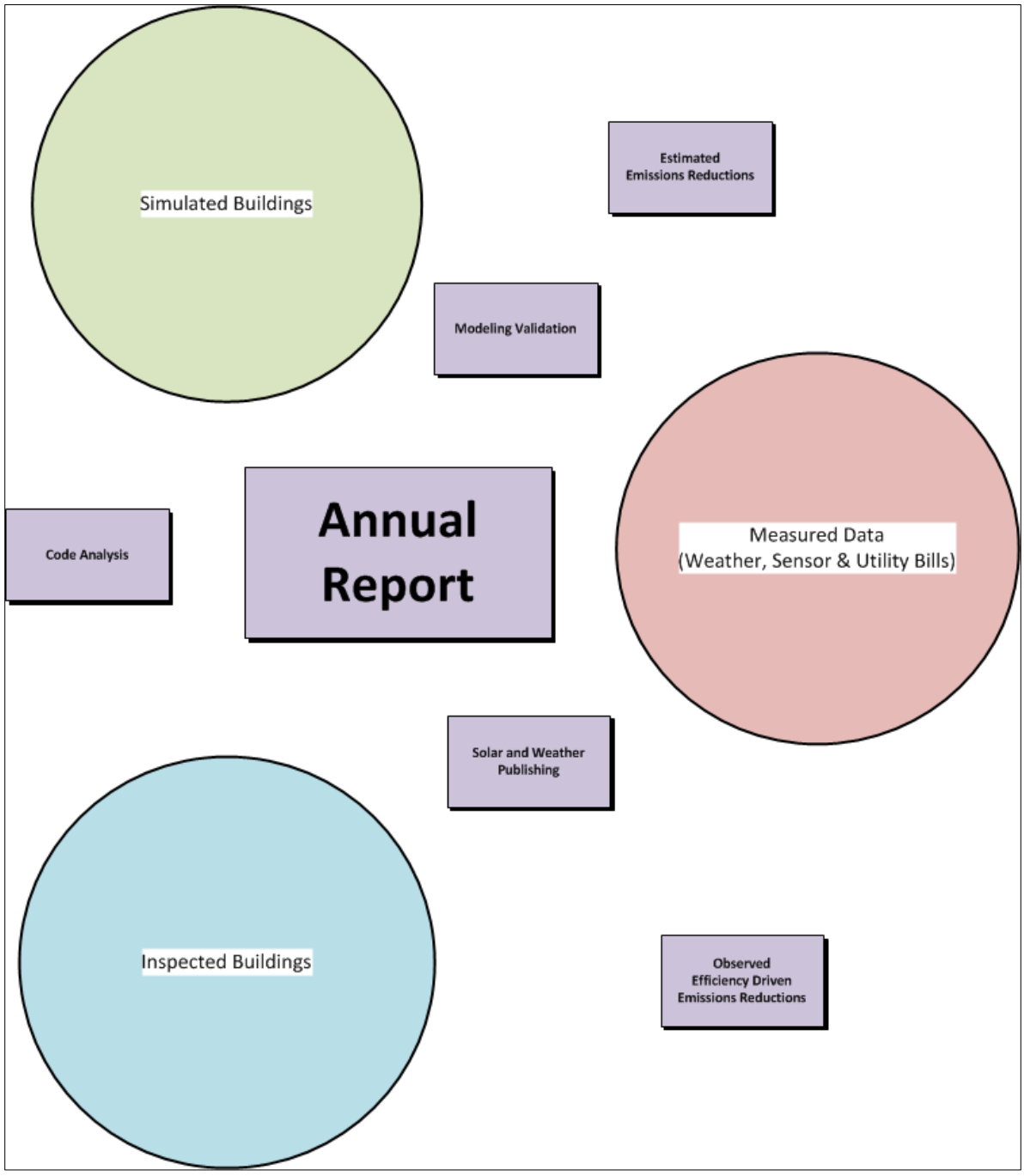

Figure 10: Registry Components

Figure 9 shows the current Registry components. There are three functional areas of the Registry. Each functional area will consist of at least one database. Raw data is typically kept in segregated areas, either as raw ASCII data or as simple SQL Server "loading tables".

SIMULATED BUILDINGS

This will be a collection of building descriptions. In the 2009 version, this was specifically the *IC3/TCV* data structure.

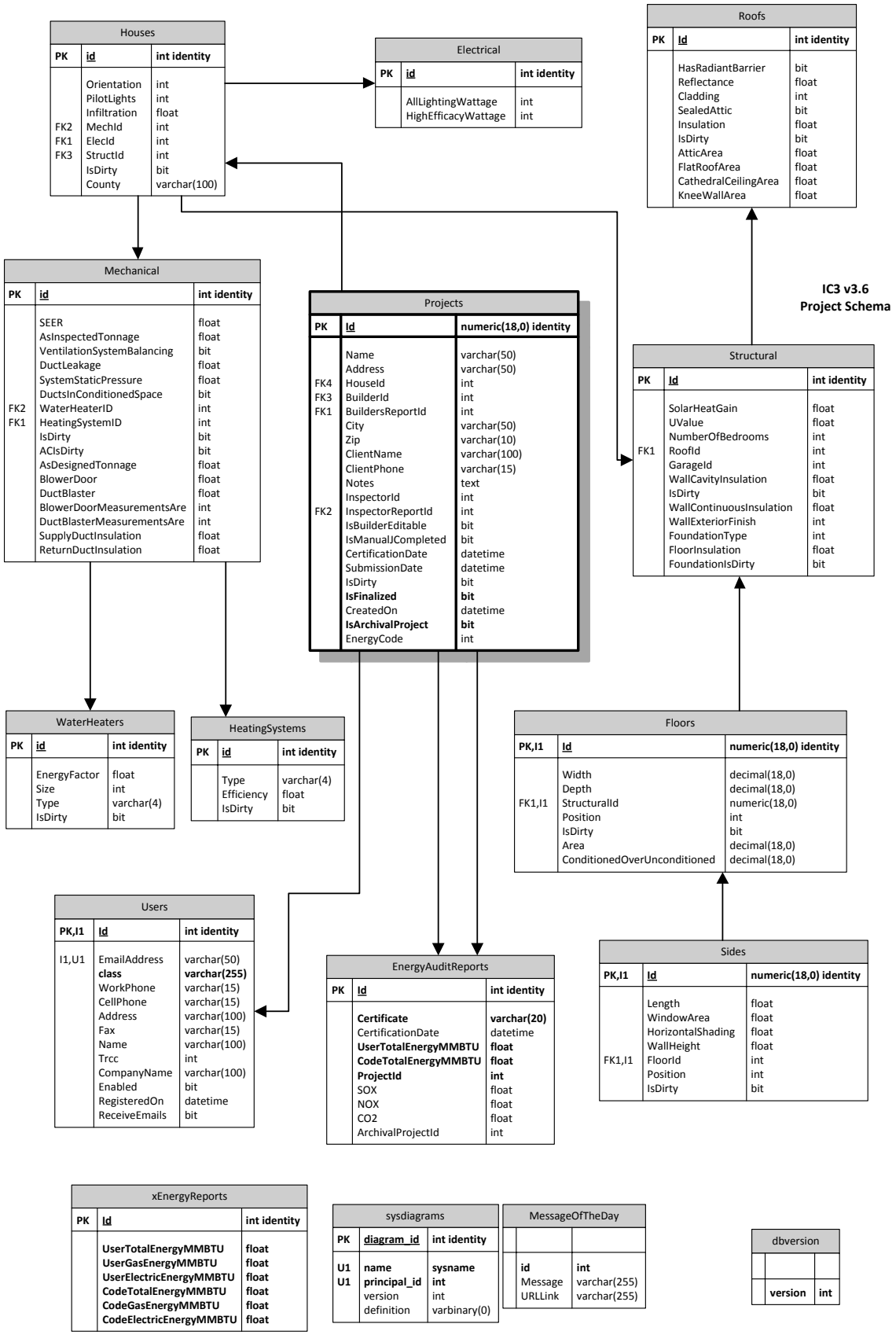

Figure 11: *IC3/TCV* Database Layout

Figure 11 shows the "schema" of the IC3 (v3.6) and TCV[6] (v1.1) databases. It gives a rough overview of the different tables (called "entities") found in the *IC3* database. The entities are linked together using "foreign keys" which allows the database to maintain a higher quality through "database integrity". The center entity is the Project, which is the center of the *IC3* software's abstraction of a house. The other tables are linked in via the foreign keys, which include floors, walls, electrical, and systems.

With the addition of future data sources (in 2010 or 2011) with building design data (i.e. *ResCheck™* or *REM/Rate™*) a new generalized schema (layout) will be created and a loading function will be added to transfer each of the unique new building descriptions to a common description. Existing reports will be saved, and new reports added to the broader and more general data. The minimum data elements are listed below:

Attribute	**Purpose**
Bldg_id	Unique registry id
Address	To locate the building for weather, jurisdiction, and potentially utility providers.
Status	New, addition, renovation, re-inspection
Square footage	Size
Energy code	Which efficiency measure applies
Year	Date of status
*floors	The number of floors.
*orientation	The direction that the front of the building faces.

* Preferred but not required.

[6] The *TCV* v1.1 database has different fields due to the built-in inspection module and the fact it was completed two years earlier than the described *IC3* v3.6.

MEASURED DATA

These will be a collection of data measures optimized for huge numbers of sensor readings from devices such as varied as portable temperature/humidity matchbook loggers to building control systems. The Laboratory's Solar Test Bench data will be collected in this section of the Registry. Finally, utility bills are a form of measured data that will be kept in the collection of linked tables.

INSPECTED BUILDINGS

Another functional module from Figure 11, the following table provides a subset of data:

Attribute	**Purpose**
Id	Unique inspection id
Bldg_id	The building id for this inspection
Inspection	Type of inspection recorded (i.e. Energy Star, IECC, local, etc)
Date	Date of inspection
Scoretype	HERS index or % above code or pass/fail
Scorevalue	The numeric value specified in scoretype
Blower door	Optional value for blower door reading
Duct blaster	Optional value for duct blaster reading

REGISTRY REPORTS

EMISSIONS REDUCTIONS ESTIMATED FROM MODELING

Estimated SOx NOx CO2 Per County from IC3 Runs

	2009.10			2009.11			2009.12			
	SOx	NOx	CO2	SOx	NOx	CO2	SOx	NOx	CO2	TOTAL
DENTON	61	113	93,841	53	100	81,395	183	346	287,910	464,002
DALLAS	107	193	156,051	121	218	175,494	81	142	115,525	447,932
COLLIN	93	170	137,682	93	173	140,808	98	178	143,331	422,626
TARRANT	79	148	121,160	53	101	83,166	94	173	140,204	345,179
ROCKWALL	29	51	40,233	21	39	32,075	46	83	67,643	140,222
RANDALL	0	1	773	15	27	21,698	25	50	42,499	65,089
BEXAR	9	18	14,643	2	3	2,676	9	15	12,118	29,493
HARRIS	2	4	3,121	7	13	10,805	11	18	14,300	28,281
TYLER	17	31	24,266				(2)	1	2,884	27,197
WICHITA	2	3	2,459				16	28	22,729	25,236
HUTCHINSON				11	22	18,246				18,278

Figure 12: *IC3* 2009 Preliminary Emissions Report

Figure 12 shows an *IC3* Emissions report that provides EPA approved emission calculations of SOx, NOx, and CO2 for the top ten counties for the last quarter of 2009.

MODELING VALIDATION

The Registry will provide the ability to validate simulated energy savings and emissions reductions by comparison with measured utility bills with weather corrections.

BUILDING CODE ANALYSIS

Having a large database of simulated and measured homes allows new code revisions (which occur every three years) to be evaluated for their impact across Texas. Historically, the Laboratory has provided this service by creating "typical" homes for a location (i.e., Houston) and simulating hundreds of variations. That activity would be enhanced considerably if actual homes, preferably with utility bills, were available for verification and validation purposes.

PUBLICATION OF SOLAR AND CONDITIONED WEATHER DATA

The Laboratory currently publishes weather data sets on its' website (Energy Systems Laboratory 2010) for use by architectural and engineering professionals who do their own modeling. The data provided includes Daily, Hourly, Daily Time Series, Hourly Time Series, TRY Format and TRY packed data formats. Presently, this data is manually processed and published using spreadsheets. The new system would allow a user to pick a location, a data format, and a date range for dynamic generation of the data from the database. This would allow custom date ranges and allow for continuous data quality improvements on the server to become available to the end user.

EMISSIONS REDUCTIONS FROM OBSERVED EFFICIENCIES

Estimating SOx, NOx, and CO2 emission reductions from simulated houses is an effective way to guide energy efficiency measures as realized in the current Code and in actual construction. However, to compare the actual values versus estimated values allows the Laboratory to maximize potential SIP[7] credits.

THE LABORATORY'S ANNUAL REPORT

Each year the Laboratory generates an Annual Report for the Texas Legislature and the Texas Commission on Environmental Quality. This report quantifies the results of the Laboratory's work to quantify credible NOx emissions because of energy efficiency and renewable energy. It provides stakeholders, government and academic researchers with a creditable basis for their emissions reduction activities for energy efficiency and renewable energy projects.

[7] State Implementation Plan (SIP) – is a Federally mandated plan for states to account for a net reduction in SOx, NOx, and CO2 emissions through energy efficiency measures.

SUMMARY

In summary, a Texas Building Registry has been created to provide data about above-code housing in Texas. The registry captures and displays projects and certificates as part of The Laboratory's *IC3* code-compliant calculator. The information and analysis from the Registry will be used to improve *IC3* and provide improve the level of detailed information about new residential construction in Texas.

ACKNOWLEDGMENTS

This work was funded by the Texas Legislature through the Texas Emissions Reduction Program (TERP).

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