2012 Avoidable Cost Rate Triennial Review

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Acronyms

AAE	Avoidable Administrative Expense
ACC	Avoidable Carrying Cost
ACLE	Avoidable Corporate Level Expenses
ACR	Avoidable Cost Rate
AME	Avoidable Maintenance Expense
AOML	Avoidable Operations and Maintenance Labor
ATFI	Avoidable Taxes Fees and Insurance
AVE	Avoidable Variable Expense
BRA	Base Residual Auction
CC	Combined Cycle
CMEC	Capacity Market Evolution Committee
CT	Combustion Turbine
EIA	Energy Information Administration
FERC	Federal Energy Regulatory Commission
FOM	Fixed Operations and Maintenance
GE	General Electric
HWI	Handy-Whitman Index
LDA	Locational Delivery Area
MC	Members Committee
MIC	Market Implementation Committee
MMU	Market Monitoring Unit
MRC	Markets and Reliability Committee
OATT	Open Access Transmission Tariff
P&W	Pratt & Whitney
PJM	PJM Interconnection, LLC
PPI	Producer Price Index
RPM	Reliability Pricing Model
RTO	Regional Transmission Operator

I. Executive Summary

In order to mitigate the potential for market power in the PJM Interconnection capacity market, known as the Reliability Pricing Model (RPM), a market structure screen identifies sellers of generation resources that are subject to Market Seller Offer Caps. These generation sellers must provide the Market Monitoring Unit (MMU) with detailed calculations and data to determine the avoidable costs used to establish the maximum allowable offer (offer cap) that would apply to their resources. Alternatively, instead of submitting this detailed information, a seller may choose to use an offer cap that is based on a default Avoidable Cost Rate (ACR) less projected revenues from other PJM markets. The ACR of a generation resource is the fixed costs necessary to allow a generation resource to remain in commercial operation. The categories of costs, which are specified in Attachment DD of the Open Access Transmission Tariff (OATT), include fixed operation and maintenance costs, certain taxes, insurance, administrative overhead, and capital investments.

The purpose of this paper is to fulfill the requirements outlined in Attachment DD section 6.7(c) of the OATT, which requires PJM to review default ACR values to:

1. Determine whether any changes other than those produced by the escalation method are warranted
2. Report its conclusions to the Members
3. File with the Federal Energy Regulatory Commission (FERC) resulting changes, if any, to the default ACR.

This review should happen after the Handy-Whitman index (a proxy for inflation related to power plant construction costs) has been used for three years.[1] The requirement originates from the PJM's Capacity Market Evolution Committee's (CMEC) decision to put into place "…annual increases in those values based on a ten year annual average rate of change in the applicable Handy-Whitman Index of Public Utility Construction Costs. The CMEC also agreed that the indexing approach should be reviewed after it has been in place for three delivery years."[2]

Recommendation #1 – Consolidation of Default Avoidable Cost Rate Categories

Default ACR cost components, values and technology categories became effective in the OATT on April 1, 2008. In all instances, these default categories were defined for specific unit models and technologies.

Based on the results of its review, PJM is proposing the current technology-specific default categories be mapped to larger technology categories that are more inclusive and do not put any undue administrative burden on any particular unit type not specifically defined in previous default categories. Based on the results of the current review, the breakout of default ACR values by technology and manufacturer specific unit types now are less necessary. The proposed new defaults, shown in Table 1 below, are designed to capture new emerging unit types as well as existing units in PJM.

[1] PJM OATT http://pjm.com/documents/~/media/documents/agreements/tariff.ashx
[2] Docket No. ER09-1673-000 http://pjm.com/~/media/documents/ferc/2009-filings/20090901-er09-1673-000.ashx p 12

Table 1: Current and Proposed Default ACR Categories

Current Default Category	Proposed Default Category
CC - NUG Cogeneration Frame B or E Technology	Combined Cycle (CC)
CC - Three on One Frame E/Siemens Technology	
CC - Three or More on One or More Frame F Technology	
CC - Two on One Frame F Technology	
CT - First & Second Generation Aero (P&W FT 4)	Combustion Turbine (CT) Aero Derivative
CT - Third Generation Aero (P&W FT-8 TwinPak)	
CT - Third Generation Aero (GE LM 6000)	
CT - First & Second Generation Frame B	Combustion Turbine (CT) Industrial Frame
CT - Second Generation Frame E	
CT - Third Generation Frame F	
Sub-Critical Coal	Coal Fired
Waste Coal - Large	
Waste Coal - Small	
Super Critical Coal	
Diesel	Diesel
Hydro	Hydro
Oil and Gas Steam	Oil and Gas Steam
Pumped Storage	Pumped Storage

To the extent that specific generation resources have specific avoidable cost values that differ from the default values, sellers of generation resources still retain the option, currently in place today, of submitting unit-specific avoidable cost data.

Recommendation #2 – Adjust for Actual Handy-Whitman Index Values When Escalating Future ACR values. Currently, PJM uses the 10-year average of the "Total Steam Production Plant" from the annual July bulletin of the *Handy-Whitman Index of Public Utility Construction Costs* to escalate default values for the future. Using the 10-year average to estimate future years is an adequate proxy for inflation before actual, realized inflation is known. It is recommended that the ACR values be corrected for inflation once the actual Handy-Whitman Index is updated to prevent any upward or downward bias in the long-term trend of default ACR values. This recommendation was made initially by PJM's Independent Market Monitor, Monitoring Analytics, in the *Analysis of the 2013/2014 RPM Base Residual Auction Revised and Updated*.[3]

[3]MMU's report on the 2013/2014 BRA, Updated and Revised
http://www.monitoringanalytics.com/reports/Reports/2010/Analysis_of_2013_2014_RPM_Base_Residual_Auction_20090920.pdf

Recommendation #3 – Update Default ACR Values to Reflect Updated Information

The following table reflects PJM's current proposed ACR values for the 2016/2017 RPM Base Residual Auction (BRA). The categories are consolidated, and include recommended new values for different technology categories.

Table 2: Proposed 2016/2017 ACR values

Current Default Category	Current 2011/2012 Mothball ACR Value	Current 2011/2012 Retirement ACR Value	Proposed Default Category	Proposed 2011/2012 Mothball ACR Value	Proposed 2011/2012 Retirement ACR Value	Proposed 2016/2017 Mothball ACR Value	Proposed 2016/2017 Retirement ACR Value
CC - NUG Cogeneration Frame B or E Technology	$120.16	$161.45	Combined Cycle (CC)	$29.58	$40.69	$36.13	$49.69
CC - Three on One Frame E/Siemens Technology	$35.89	$48.60					
CC - Three or More on One or More Frame F Technology	$27.98	$38.85					
CC - Two on One Frame F Technology	$32.33	$45.85					
CT - First & Second Generation Aero (P&W FT 4)	$25.69	$34.17	Combustion Turbine (CT) Aero Derivative	$26.13	$37.18	$31.91	$45.41
CT - Third Generation Aero (GE LM 6000)	$58.42	$86.10					
CT - Third Generation Aero (P&W FT-8 TwinPak)	$30.64	$45.17					
CT - First & Second Generation Frame B	$25.38	$33.87	Combustion Turbine (CT) Industrial Frame	$24.13	$33.04	$29.47	$40.35
CT - Second Generation Frame E	$24.13	$32.29					
CT - Third Generation Frame F	$24.77	$35.68					
Sub-Critical Coal	$178.24	$197.58	Coal Fired	$136.91	$157.83	$167.21	$192.76
Waste Coal - Large	$86.94	$105.02					
Waste Coal - Small	$235.06	$284.70					
Super Critical Coal	$184.15	$201.42					
Diesel	$27.49	$34.91	Diesel	$25.46	$32.33	$31.09	$39.49
Hydro	$74.24	$97.10	Hydro	$68.78	$89.96	$84.00	$109.86
Oil and Gas Steam	$68.18	$83.01	Oil and Gas Steam	$63.16	$76.90	$77.14	$93.91
Pumped Storage	$21.72	$30.50	Pumped Storage	$20.12	$28.26	$24.57	$34.51

For the 2016/2017 values proposed by this paper, they should not be final until the 2012 Handy-Whitman Index is available and the reported 2011/2012 ACR values have been adjusted. (See: Section VI: Handy Whitman Index)

II. Introduction and the Role of Avoidable Costs in RPM

The PJM capacity market, known as the Reliability Pricing Model (RPM), ensures the adequate availability of necessary resources that can be called upon to ensure the reliability of the grid. RPM aligns capacity pricing with system reliability requirements and provides transparent information to all market participants three years in advance of delivery to facilitate actionable response to the information. The fundamental elements of RPM are:

1. Locational capacity price to recognize and quantify the locational value of capacity;
2. Downward sloping demand curve (Variable Resource Requirement) that recognizes the value of capacity beyond the target installed reserve margin;
3. Three-year forward commitment of supply by generation, demand resources, energy efficiency resources and qualified transmission upgrades cleared in a multi-auction structure.

In RPM, offers of existing generation capacity suppliers to provide capacity to PJM, assuming they do not pass market power screens, are capped at a price based on their Avoidable Cost Rate (ACR) less the projected revenues from other PJM markets. To the extent that default ACR values are employed in the capped offers made by existing generation resources, their values have an effect on price formation in RPM auctions. The PJM Open Access Transmission Tariff (OATT) specifies default ACR values for various generation technologies and for both mothball and retirement scenarios. Section 6.7 (c) of Attachment DD of the PJM OATT provides default ACR values specific to the Base Residual Auction (BRA) for the 2012/2013 delivery year and describes a methodology for adjusting these specific default ACR values to determine updated default ACR values for use in the BRAs for the next three consecutive delivery years (2013/2014, 2014/2015 and 2015/2016 delivery years). In the most recent BRA for the delivery year 2015/2016, 38.4% of generation resources (449 units) decided to use only the default ACR values. [4]

Description of Avoidable Cost Rates

In RPM, if a market structure screen identifies sellers that are deemed to possess market power and, by definition, have the ability to raise prices above competitive levels, those sellers must provide the PJM Market Monitor with documentation of expected energy and ancillary service market revenues and avoidable costs to establish a market seller offer cap that would apply to each of their resources. Alternatively, instead of submitting detailed avoidable cost calculations the seller may choose to use default avoidable cost values that are specific to the unit type. [5] The default rates currently in place in the tariff rely on the original values submitted by PJM in 2007.[6] These estimates were typical, but not exhaustive, as "the seller always has the option of simply showing and supporting its costs to PJM."[7] So, the use of default ACRs made offering into RPM simpler for suppliers that were amenable to their use.

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[4] Section 4 State of the Market Report http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2012/2012q2-som-pjm-sec4.pdf

[5] OATT Attachment DD 6.7c http://pjm.com/documents/~/media/documents/agreements/tariff.ashx

[6] FERC Submittal 20070926-0113 for docket ER05-1410-006 and EL05-148-006 on September 24, 2007; Page 14. These rates were developed as "detailed estimates…of the costs of a resource in each asset class… (and) detailed line item estimates in each cost category."

[7] FERC Submittal 20070926-0113 for docket ER05-1410-006 and EL05-148-006 on September 24, 2007; Page 15

Avoidable costs are defined as the incremental costs of being a capacity resource and the fixed annual operating expenses that would not be incurred if a unit were not a capacity resource for a year.

> *"Avoidable costs are the portion of the fixed annual operating expenses of the generating unit if not participating in the capacity market for one year… (the) unit is shutdown, laid up, secured, insured, in working order and state of repair to return to the next year capacity market."* [8]

Through the capacity market PJM sends forward investment signals to certain areas and better ensures that units can cover their going forward costs. [9]

Requirement in the Open Access Transmission Tariff

The purpose of this paper is to fulfill the requirements outlined in Attachment DD section 6.7(c) of the PJM Open Access Transmission Tariff:

"The default Avoidable Cost Rates referenced in section (c) (ii) above are as set forth in the tables below for any auction conducted after September 1, 2009 for any Delivery Year through the 2012-2013 Delivery Year. To determine the default ACR values for the 2013-2014 and subsequent Delivery Years, the Office of the Interconnection shall multiply the ACR values for the immediately preceding Delivery Year by a factor equal to the most recent ten-calendar-year annual average rate of change in the applicable Handy-Whitman Index of Public Utility Construction Costs or a comparable index approved by the Commission, as calculated by the Office of the Interconnection and posted to its Web site; provided, however, that after the Handy-Whitman indexing methodology has been employed to determine the default ACR values for the RPM Auctions for three consecutive Delivery Years, the Office of the Interconnection shall:

i) ***review the default ACR values*** *to determine whether any changes other than those produced by such methodology are warranted* ***for subsequent Delivery Years*** *(including seeking the analysis and advice of the Market Monitoring Unit on such matter) and* ***report its conclusions*** *to the Members in writing no later than four months after the Base Residual Auction for the third such Delivery Year; and*

ii) ***file with FERC resulting changes****, if any, to this section no later than seven months after such Base Residual Auction, to be effective for the Base Residual Auction for the following Delivery Year; provided further, that nothing herein precludes the Office of the Interconnection from filing with FERC changes to the default ACR values or any other provision of this section prior to the deadline stated in the previous clause, or at any other time."* [1] ***(emphasis added)***

The 2015/2016 BRA conducted in May 2012 was the third consecutive delivery year in which the adjustment methodology has been employed; consequently, a review of the default ACR values is required in 2012. The

[8] MMU's presentation on ACR http://www.monitoringanalytics.com/reports/Presentations/2006/20061108-rpm-workshop-avoidable-cost-rate-dev.pdf

[9] However, RPM is not a guarantee like a RMR contract; it is a market and includes costs and risks of doing business.

2015/2016 BRA concluded May 18, 2012; therefore, a report of the review is due to PJM members no later than September 18, 2012. If the review shows that changes to the default ACR values are warranted, then these changes should be filed with the FERC no later than December 18, 2012.

Goals of the Review

The two goals in this review are: (1) maintain, to the extent possible, consistent and stable benchmark of costs so market participants know what they can expect in future capacity auctions; and (2) reflect actual costs as accurately as possible for classes of generation resources. The default ACR values are a benchmark of the "typical unit type's" fixed, avoidable costs. The owner of any unit that does not fit into this category can document its specific costs to PJM and the Market Monitoring Unit in a unit specific ACR calculation.

In order to achieve these goals, it is necessary to answer three questions:

- Are the current default values as detailed in the OATT appropriate?
- Is the current escalation method using the Handy-Whitman Index appropriate?
- What are the best categories and values to use in future RPM auctions?

To develop the recommendations contained in this paper, PJM reviewed previous RPM auction data, unit specific ACR submissions, survey data from current generation owners regarding their 2011 ACR components, The Brattle Group's *Cost of New Entry Estimates for Combustion Turbine and Combined Cycle Plants in PJM*, and the U.S. Energy Information Administration-commissioned RW Beck's *Updated Capital Cost Estimates for Electricity Generation Plants*.

III. History of Default Avoidable Cost Rates

How Default ACR came to be specified in the OATT

The FERC found that PJM's capacity market prior to RPM was unjust and unreasonable as it had failed to procure enough capacity in certain areas "to enable PJM to fulfill its obligation to maintain a reliable transmission system."[10] PJM developed the Reliability Pricing Model, a structure in which owners of capacity resources would offer capacity and PJM would purchase enough capacity to meet reliability needs on a multi-year forward basis with a single clearing price for all capacity. FERC conditionally approved RPM on December 22, 2006[11].

A generator's maximum allowable offer into RPM is based on its Avoidable Cost Rate less projected revenues from other PJM markets. Initially within RPM, capacity sellers could choose one of two options for their ACR values: (1) provide unit-specific ACR data to the Market Monitor or (2) choose to use a default unit ACR value determined by the Market Monitor.

[10] April 20 Order, 115 FERC ¶ 61,079 at P 1-6.

[11] *See* December 22, 2008 Order, 117 FERC ¶ 61,331 at P 1.

The FERC found that the RPM settlement, which created the new capacity market with these options, "granted excessive discretion to PJM's Market Monitoring Unit (MMU) in certain areas….Because the Commission was concerned that, in developing these default bids, the MMU might exercise excessive discretion, it ordered PJM to replace the discretionary provisions with objective factual criteria to be used in developing or reviewing default bids."[12]

PJM proposed to remove the MMU's discretion with respect to all default rates by placing the default ACR by technology category into the OATT. The values are specified and escalated using a 10-year average of the Handy-Whitman Index to escalate for future years [13]

Meaning of Avoidable Percentages

Avoidable costs are costs a generating unit would avoid if it mothballed or retired. So, the avoidable mothball percentages are the percentage of costs that a generating resource would avoid if it were mothballed for a single year but were maintained in a state that allowed it to be placed back in service. These costs are calculated by multiplying the components of ACR by a percentage of those costs that could be avoided. Retirement ACR values assume that the resource would retire permanently and all future fixed costs would be avoidable.

Components of ACR

Equation 1: Components of Default ACR

$$\textit{Avoidable Cost Rate} = [\textit{Adjustment Factor} * (\textit{AOML} + \textit{AAE} + \textit{AME} + \textit{AVE} + \textit{ATFI} + \textit{ACC} + \textit{ACLE})]$$

Where:

- **Adjustment Factor** equals 1.10 (to provide a margin of error for understatement of costs) plus an additional adjustment referencing the 10-year average Handy-Whitman Index in order to account for expected inflation from the time interval between the submission of the sell offer and the commencement of the delivery year.

- **AOML (Avoidable Operations and Maintenance Labor)** consists of the avoidable labor expenses related directly to operation and maintenance of the generating unit for the 12 months preceding the month in which the data must be provided. The categories of expenses included in AOML are those incurred for: (a) on-site-based labor engaged in operations and maintenance activities; (b) off-site-based labor engaged in on-site operations and maintenance activities directly related to the generating unit; and (c) off-site-based labor

[12] FERC Order Conditionally Accepting Compliance Filing ER05-1410-007 and ER05-148-007 07/18/2008 http://www.pjm.com/~/media/documents/ferc/2008-orders/20080718-er05-1410-007.ashx

[13] PJM filed to put default ACR values into the OATT on September 24, 2007 (RE: PJM Interconnection, LLC, Docket ER05-1410-006 and EL05-148-006), putting the values into the OATT was conditionally approved by FERC March 21, 2008 122 FERC ¶ 61,264 and became effective April 1, 2008 and utilized in the 2011/2012 BRA.

engaged in off-site operations and maintenance activities directly related to generating unit equipment removed from the generating unit site.

- **AAE (Avoidable Administrative Expenses)** consists of the avoidable administrative expenses related directly to employees at the generating unit for 12 months preceding the month in which the data must be provided. The categories of expenses included in AAE are those incurred for: (a) employee expenses (except employee expenses included in AOML); (b) environmental fees; (c) safety and operator training; (d) office supplies; (e) communications; and (f) annual plant test, inspection and analysis.

- **AME (Avoidable Maintenance Expenses)** consists of avoidable maintenance expenses (other than expenses included in AOML) related directly to the generating unit for the 12 months preceding the month in which the data must be provided. The categories of expenses included in AME are those incurred for: (a) chemical and materials consumed during maintenance of the generating unit; and (b) rented maintenance equipment used to maintain the generating unit.

- **AVE (Avoidable Variable Expenses)** consists of avoidable variable expenses related directly to the generating unit incurred in the 12 months preceding the month in which the data must be provided. The categories of expenses included in AVE are those incurred for: (a) water treatment chemicals and lubricants; (b) water, gas, and electric service (not for power generation); and (c) waste water treatment.

- **ATFI (Avoidable Taxes, Fees and Insurance)** consists of avoidable expenses related directly to the generating unit incurred in the 12 months preceding the month in which the data must be provided. The categories of expenses included in AFTI are those incurred for: (a) insurance, (b) permits and licensing fees, (c) site security and utilities for maintaining security at the site; and (d) property taxes.

- **ACC (Avoidable Carrying Charges)** consists of avoidable short-term carrying charges related directly to the generating unit in the 12 months preceding the month in which the data must be provided. Avoidable short-term carrying charges shall include short-term carrying charges for maintaining reasonable levels of inventories of fuel and spare parts that result from short-term operational unit decisions as measured by industry best practice standards. For the purpose of determining ACC, short term is the time period in which a reasonable replacement of inventory for normal, expected operations can occur.

- **ACLE (Avoidable Corporate Level Expenses)** consists of avoidable corporate level expenses directly related to the generating unit incurred in the 12 months preceding the month in which the data must be provided. Avoidable corporate level expenses shall include only such expenses that are directly linked to providing tangible services required for the operation of the generating unit proposed for deactivation. The categories of avoidable expenses included in ACLE are those incurred for: (a) legal services, (b) environmental reporting; and (c) procurement expenses.

For the purpose of determining an Avoidable Cost Rate, avoidable expenses are incremental expenses directly required to operate a generation capacity resource that a generation owner would not incur if such generating unit did not operate in the delivery year or meet availability criteria during peak-hour periods during the delivery year.[14] Avoidable expenses do not include variable costs recoverable under cost-based offers to sell energy from operating capacity on the PJM Energy Market under the Operating Agreement. [15]

IV. Descriptions of the current technology categories[16]

Combined Cycle – Non-Utility Generator Cogeneration Frame B or E Technology

Combined Cycle – Non-Utility Generator Cogeneration Frame B or E Technology default category is based on a General Electric PG7121EA, consisting of one 80-megawatt (MW) combustion turbine (CT) and one 40-MW heat recovery steam generator unit running primarily on natural gas with onsite compression and No. 2 oil as a backup fuel built in 1989. These units are assumed to have dry low NOx burners, selective catalytic control and a wet cooling tower for condenser cooling.

Combined Cycle – Three or More on One or More Frame F Technology

Combined Cycle – Three or More on One Frame F Technology default category is based on a General Electric PG7241FA, consisting of a bank of three CTs (171.7 MW each) and one heat recovery steam generator unit (390 MW) running solely on natural gas built in 2003. These units are assumed to have dry low NOx burners, selective catalytic control, evaporative turbine inlet air cooling technology and a wet cooling tower for condenser cooling.

Combined Cycle – Two on One Frame F Technology

Combined Cycle – Two on One Frame F Technology default category is based on a General Electric PG7241FA, consisting of a bank of two CTs (171.7 MW each) and one heat recovery steam generator unit (200 MW) running solely on natural gas with onsite compression built in 2003. These units are assumed to have dry low NOx burners, selective catalytic control and NOx control, evaporative turbine inlet air cooling technology and a wet cooling tower for condenser cooling.

Combined Cycle – Three on One Frame E/Siemens Technology

Combined Cycle – Three on One Frame E/Siemens Technology default category is based on a Siemens V84.2, consisting of a bank of three CTs (105 MW each) and one heat recovery steam generator unit (250 MW) running primarily on natural gas with onsite compression and No. 2 oil as a backup built in 2003. These units are assumed to have dry low NOx burners, selective catalytic control, evaporative turbine inlet air cooling technology and a wet cooling tower for condenser cooling.

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[14] PJM OATT http://pjm.com/documents/~/media/documents/agreements/tariff.ashx
[15] Order conditionally accepting compliance filing re PJM Interconnection, LLC under ER05-1410 http://elibrary.ferc.gov:0/idmws/file_list.asp?document_id=13630930
[16] All information in section 4 is taken from http://www.monitoringanalytics.com/reports/Reports/2007/20070202-simplified-pjm-rpm-default-acr-proxy-plants.xls

Combustion Turbine – First & Second Generation Aero (P&W FT 4)

Combustion Turbine – First & Second Generation Aero (P&W FT 4) default category is based on a bank of 10 20-MW Pratt & Whitney FT4A8 units running primarily on No. 2 oil with a natural gas backup and onsite natural gas compression built in 1970.

Combustion Turbine – Third Generation Aero (GE LM 6000)

Combustion Turbine – Third Generation Aero (GE LM 6000) default category is based on a bank of two 44-MW General Electric LM6000 units running primarily on natural gas with No. 2 oil as a backup built in 2001. These units are assumed to have water injection for NOx control and evaporative turbine inlet air cooling technology.

Combustion Turbine – Third Generation Aero (P&W FT-8 TwinPak)

Combustion Turbine – Third Generation Aero (P&W FT-8 TwinPak) default category is based on a bank of six 50-MW Pratt & Whitney FT8 TwinPak units running primarily on natural gas with No. 2 oil as a backup built in 2003. These units are assumed to have water injection for NOx control and evaporative turbine inlet air cooling technology.

Combustion Turbine – First & Second Generation Frame B

Combustion Turbine – First and Second Generation Frame B default category is based on a bank of 10 20-MW Frame 5B units running primarily on No. 2 oil with a natural gas backup built in 1970.

Combustion Turbine – Second Generation Frame E

Combustion Turbine – Second Generation Frame E default category is based on a bank of eight 80-MW General Electric PG7121EA natural gas units with onsite natural gas compression built in 2001. These units are assumed to have dry low NOx burners and evaporative turbine inlet air cooling technology.

Combustion Turbine – Third Generation Frame F

Current default category is based on a bank of two 171.2-MW General Electric PG7241FA gas units with onsite natural gas compression built in 2001. These units are assumed to have dry low NOx burners and evaporative turbine inlet air cooling technology.

Diesel

The original category of diesel is based on a Caterpillar diesel generator running on No. 2 oil with an installed capacity value of five megawatts each in a pack of 12 units built in 2002.

Hydroelectric Unit (Hydro)

The hydro category is based on a bank of ten 50-MW General Electric turbines.

Oil and Gas Steam

The original category of oil and gas steam was based on two front-wall-fired Foster Wheeler boilers and two General Electric steam turbines units (125 MW each) running on No. 6 oil with a backup fuel of natural gas built in 1955. These units are assumed to have low NOx burners and overfire air to control NOx. Particulate control is handled with electrostatic precipitators and cyclones. The unit is assumed to have a wet cooling tower.

Pumped Storage

The pumped storage category is based on a bank of eight 125-MW General Electric turbines and five pumps.

Sub-Critical Coal

The sub-critical coal category is based on a front-wall-fired Foster Wheeler boiler with a General Electric steam turbine generator (525 MW) running primarily on coal and having No. 2 oil as a backup fuel. The unit is assumed to have low NOx burners and overfire air to control NOx. Particulate control is handled with cyclones and a bag house as well as electrostatic precipitators. SO_2 is controlled with dry injection technology, and the unit is assumed to cool the condensers with river water.

Waste Coal – Large

The large waste coal category is based on a pack of two Foster Wheeler circulating fluidized bed boilers running on waste coal with No.2 oil as a backup fuel. The unit has one General Electric Steam Generator (540 MW) and controls NOx with overfire air and urea injection. Particulate control is handled with cyclones and a bag house as well as electrostatic precipitators. SO_2 is controlled with dry lime injection technology, and the unit is assumed to cool the condensers with river water

Waste Coal – Small

The small waste coal category is based on a pack of two Foster Wheeler circulating fluidized bed boilers running on waste coal with No.2 oil as a backup fuel. The unit has one General Electric steam generator (100 MW) and controls NOx with overfire air and urea injection. Particulate control is handled with cyclones and a bag house as well as electrostatic precipitators. SO_2 is controlled with dry injection technology, and the unit is assumed to cool the condensers with river water

Super-Critical Coal

The super-critical coal category is based on a front-wall-fired Foster Wheeler boiler with a General Electric steam turbine generator (630 MW) running primarily on coal and having No. 2 oil as a backup fuel. The unit is assumed to have low NOx burners and overfire air to control NOx. Particulate control is handled with cyclones and a bag house as well as electrostatic precipitators. SO_2 is controlled with a wet scrubber technology, and the unit is assumed to cool the condensers with river water.

V. Methodology

Review of Similar Studies

Prior to engaging in this study, PJM reviewed similar studies for guidance on existing costs for generating units. There are many estimates for fixed costs for power plants. In order to capture the most recent trends, only studies conducted after 2009 were considered. The most recent studies that include recent fixed operations and maintenance cost numbers are The Brattle Group's report for PJM on the *Cost of New Entry Estimates for Combustion Turbine and Combined Cycle Units* and a report commissioned by the Energy Information Association entitled *Updated Capital Cost Estimates for Electricity Generation Plants.* Fixed operations and maintenance costs reported for different unit types could be used to derive estimated default mothball ACR values using the original percent avoidable filed with the FERC.[17]

Cost of New Entry Estimates for Combustion Turbine and Combined Cycle Plants in PJM[18]

On August 24, 2011, The Brattle Group, with inputs provided by CH2M HILL and Wood Group Power Operations, published a report for PJM in which it prepared estimates of capital and ongoing fixed operating costs for a new plant "for consideration by PJM Interconnection and stakeholders as they update the administrative CONE[19] parameters for PJM's capacity market, the Reliability Pricing Model". In Brattle's development of Cost of New Entry (CONE) estimated the fixed operations and maintenance costs for two unit types:

1. Combustion turbine based on a GE 7FA.05 turbine, and
2. Combined cycle based on two GE 7FA.05 turbines each with a heat recovery steam generator and one shared reheat steam generator.[20]

Table 2 in the Brattle report contains an estimate of fixed operations and maintenance cost in $/kw-year for 2015/2016. According to Brattle, "Once the plant enters commercial operation, the plant owners incur fixed costs each year, including property taxes, plant insurance, facility fees for operating labor and minor maintenance, and asset management costs..."[21] The costs used in Brattle's calculation are similar to ACR costs.[22] For example, property taxes and plant insurance would fall in part under avoidable taxes, fees and insurance, a component of

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[17] Filed September 24, 2007 PJM Compliance Filing p 15 "… each cost category has a different 'percent avoidable'. Under this approach the calculated percentage for each cost category assumes that the resource is mothballed for one year, but not retired"

[18] http://www.pjm.com/~/media/committees-groups/committees/mrc/20110818/20110818-brattle-report-on-cost-of-new-entry-estimates-for-ct-and-cc-plants-in-pjm.ashx

[19] Cost of New Entry is the levelized annual cost in ICAP $/MW-Day of a reference combustion turbine to be built in a specific location.

[20] http://www.pjm.com/~/media/committees-groups/committees/mrc/20110818/20110818-brattle-report-on-cost-of-new-entry-estimates-for-ct-and-cc-plants-in-pjm.ashx Brattle Report page 17

[21] http://www.pjm.com/~/media/committees-groups/committees/mrc/20110818/20110818-brattle-report-on-cost-of-new-entry-estimates-for-ct-and-cc-plants-in-pjm.ashx page 29

[22] See Components of ACR costs on Page 10

ACR. Fixed operating expenses include staff labor costs, consumables, administration fees and corporate overhead, which Brattle describes as "The largest component of the fixed operating expenses is the staff labor costs, accounting for approximately half of the total fixed O&M costs depending on plant type and location. The remaining annual O&M services costs are comprised of consumables, office administration, maintenance and minor repairs, and corporate and administrative charges." These costs are similar to avoidable operations maintenance labor, avoidable maintenance expense, avoidable administrative expenses and avoidable corporate level expenses. However, the fixed operations and maintenance cost values in the Brattle report do not line up perfectly with the components of ACR, and they are not entirely avoidable.

The table below shows the fixed operations and maintenance costs taken from the Brattle report and the mothball percent avoidable taken from the FERC filing[23] of ACR defaults. In this way an implied ACR is estimated for future delivery years.[24]

Table 3: ACR values derived from the Brattle Study on CONE[25]

	Brattle Combined Cycle	Brattle Combustion Turbine
Fixed 2015/2016 O&M kw-year	$16.00	$15.20
% Avoidable	70.5%	69.4%
2011/2012 Implied Mothball ACR $/MW-day	$26.32	$24.62
2011/2012 Implied Retirement ACR $/MW-day	$37.33	$35.47
2016/2017 Implied Mothball ACR $/MW-day	$32.16	$30.08
2016/2017 Implied Retirement ACR $/MW-day	$45.62	$43.34

The benefit of this calculation is that it is useful as a bottom up estimate of fixed avoidable costs of new combustion turbines and combined cycle units in the PJM region. The disadvantages are that fixed operation and maintenance costs do not directly compare with ACR values even when using an avoidable cost percentage. The Brattle report shares similar terminology and calculations with ACR calculations, but many assumptions are different; therefore, numbers derived by the report should be used a guide but not as a true representation of 2016/2017 default ACR costs.[26]

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[23] FERC Submittal 20070926-0113 for docket ER05-1410-006 and EL05-148-006 on September 24, 2007; Attachment B

[24] It is assumed the 2015/2016 estimate can be used for the 2015/2016 implied ACR. Then the 10-year average of the HWI of 4.09%to get the 2016/2017 delivery year ACR estimate.

[25] http://www.pjm.com/~/media/committees-groups/committees/mrc/20110818/20110818-brattle-report-on-cost-of-new-entry-estimates-for-ct-and-cc-plants-in-pjm.ashx These values are for RTO only Table 2 Page 3

[26] See Components that make up ACR on Page 10

EIA Study: Updated Capital Cost Estimates for Electricity Generation Plants.

Released in November 2010, the Energy Information Administration study, *Updated Capital Cost Estimates for Electricity Generation Plants*[27], estimates the cost to build and run current technologies. The study also repeats the conclusion that there has been considerable change in costs. "The current and projected future costs of energy-related capital projects, including but not limited to new electric generating plants, have been subject to considerable change in recent years." [28] Although, EIA continually updates performance and cost assumptions, in 2011 "…EIA commissioned an external consultant to develop current cost estimates for utility-scale electric generating plants."[29]

Fixed operations and maintenance costs in this study include staffing costs, bonuses, plant support equipment, administrative expenses, routine and preventative maintenance, maintenance of buildings and grounds, and administrative costs. These costs fall under similar categories used in the calculation of ACR (See: Cost Components of ACR). To recast the estimates in the EIA study so they could be used for comparison, mothball percent avoidable was estimated by technology type and used to escalate the EIA 2010 value to forecast 2016/2017 ACR estimates. Because there are no estimates for what percent avoidable would be for some of these categories, estimated avoidable percentages were approximated from similar unit types.[30]

Table 4: ACR values derived from EIA study

[27] EIA study http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf

[28] EIA study description http://www.eia.gov/oiaf/beck_plantcosts/

[29] EIA study description http://www.eia.gov/oiaf/beck_plantcosts/

[30] EIA estimated in 2010 $/kw-year. After converting to $ per MW-day and estimating inflation at the 2011 HWI and then using 4.09% or the 10-year average to get 2011/2012 to an estimated 2015/2016 value. Single Unit Advanced Pulverized Coal and Dual Unit Pulverized Coal Category use the Super-Critical Coal Avoidable mothball percent. Conventional Natural Gas Combined Cycle category and Advanced Natural Gas Combined Cycle use the Combined Cycle- Two on One Frame F mothball Avoidable percent. The Conventional Combustion Turbine uses the Combustion Turbine Second Generation Frame E mothball Avoidable percent. The Advanced Combustion Turbine uses the Combustion Turbine Third Generation Frame F mothball Avoidable percent

	2010 $/kW-yr	2010 $/MW-day	Avoidable Mothball %	2011/2012 Mothball ACR $/MW-day	2011/2012 Retirement ACR $/MW-day	2016/2017 Mothball ACR $/MW-day	2016/2017 Retirement ACR $/MW-day
Single Unit Advanced Pulverized Coal	$35.97	$98.55	91.40%	$94.37	$103.25	$115.31	$126.16
Dual Unit Advanced Pulverized Coal	$29.67	$81.29	91.40%	$77.84	$85.17	$95.12	$104.07
Conventional Natural Gas Combined Cycle	$14.39	$39.42	70.50%	$29.12	$41.30	$35.58	$50.47
Advanced Combined Cycle	$14.62	$40.05	70.50%	$29.58	$41.96	$36.15	$51.27
Conventional Combustion Turbine	$6.98	$19.12	74.70%	$14.96	$20.03	$18.28	$24.48
Advanced Combustion Turbine	$6.70	$18.36	69.40%	$13.35	$19.24	$16.31	$23.50
Hydro	$13.44	$36.82	76.50%	$29.51	$38.58	$36.06	$47.14
Pumped Hydro	$13.03	$35.70	71.20%	$26.63	$37.40	$32.54	$45.70

These values serve as a benchmark for comparison with the current default values in the tariff and for the survey results discussed below. The values from these studies also inform the proposed updates for the default ACR values.

Survey Approach

PJM surveyed market participants about their current unit-specific avoidable costs. PJM requested that all members owning generation units defined in current ACR categories fill out a survey to provide unit information and to estimate their ACR for calendar year 2011. Respondents were asked to calculate their total costs for each of the cost components in ACR and their estimated percent avoidable. PJM announced the survey at multiple stakeholder meetings [31] and sent a letter requesting responses to 2,737 email addresses. Survey responses were received from 23 companies, giving a sample size of 337 units out of a potential of 670 units that are in a default ACR category. PJM reviewed this information and used it, in part, to develop the new categories and new default values that are being recommended.

[31] System Operating Subcommittee, Cost Development Subcommittee .Operating Committee, Markets and Reliability Committee, Market Implementation Committee, Capacity Senior Task Force

Benefits of this method

One of the benefits of this method is that PJM was able to analyze actual data from real PJM market participants. PJM preferred using actual participant data because it would represent the population of units currently in PJM. With a survey, PJM was able to gather information to benchmark ACR using the existing resource stock in PJM's footprint.

Issues with this method

A drawback to the survey method is that the survey was voluntary, so all participants were self-selected. Additionally, the data provided by PJM members was not auditable by PJM. Participants with low costs could choose not to respond or could respond only with their higher cost units. However, any survey that is not auditable and mandated for all participants must consider this potential bias and calls for benchmarks from studies such as those from Brattle and EIA.

In discussions with the Market Monitor, it was agreed that a more robust method would be to mandate response and with a team of auditors determine a representative conglomeration of costs. However, PJM did not find such measures necessary because PJM was not looking for data used for a specific unit but rather for benchmark representative unit in each category, the sample itself can be modified and analyzed to give a better idea of whether the current ACR values are appropriate. To alleviate sample bias, the median [32] was used instead of the mean to mitigate possible inflated survey results. The mean would be pulled upward by large outliers; this has little to no effect on the median. This decision was validated when an analysis showed that the distributions of survey responses were bimodal, meaning that they had two groupings of data usually at and around the median with a smaller grouping at a higher cost.

[32] The median is the number in the exact middle of the range if ranked from highest to lowest.

Results from the survey

	Total in PJM	Sample	%
CC - Three or More on One or More Frame F Technology	11	1	9%
CC - Two on One Frame F Technology	51	9	18%
CT - First & Second Generation Aero (P&W FT 4)	119	92	77%
CT - Third Generation Aero (GE LM 6000)	47	20	43%
CT - Third Generation Aero (P&W FT-8 TwinPak)	26	4	15%
CT - First & Second Generation Frame B	110	51	46%
CT - Second Generation Frame E	71	26	37%
CT - Third Generation Frame F	62	1	2%
Diesel	57	7	12%
Hydro	33	18	55%
Oil and Gas Steam	33	25	76%
Pumped Storage	15	6	40%
Sub-Critical Coal	139	35	25%
Super-Critical Coal	59	42	71%
TOTAL	**833**	**337**	**40%**

No Response - PJM was unable to evaluate the following unit types due to lack of survey data:

- Waste Coal – Small
- Waste Coal – Large
- Combined cycle – Three on One Frame E/Siemens Technology
- Combined cycle – NUG Cogeneration Frame B or E Technology

Due to the lack of survey data on these unit types, as part of the proposed consolidation of default ACR types, PJM recommends consolidating Waste Coal – Small and Large into Coal Fired Units; combined cycle – Three on One Frame E/Siemens Technology and combined cycle – NUG Cogeneration Frame B or E Technology into Combined Cycle. In this review, PJM is proposing the default categories be changed to be more inclusive and not put any undue administrative burden on any particular unit type not defined in previous default categories.

If PJM received less than seven units in a class or less than three companies submitted the unit type, the technology class was not evaluated. Further, if the units received were all at the same plant, the units counted as one unit. The following did not have the necessary sampling diversity to use their information without biasing the result for or against a particular market participant:[33]

- Combined cycle – Two on One Frame F Technology

[33]PJM Manual 33: Administrative Services for the PJM OA http://pjm.com/~/media/documents/manuals/m33.ashx Page 22

- Combustion turbine – Third Generation Aero (P&W FT- 8 TwinPak)
- Combustion turbine – Third Generation Frame F
- Diesel
- Pumped Storage
- Hydro

The survey data were analyzed in two ways: using the avoidable percentages provided by participants and also by using the avoidable percentages used in the development of the original ACR values (and in turn approved by FERC). In review of both methods, PJM and the Market Monitor determined that the default avoidable percentages for mothballing a unit would be the best estimate of mothball ACR values. Once these values were calculated, PJM ran tests on each sample to see if the average ACR costs were statistically different from the 2011/2012 mothball ACR values. The p-value is the probability using a typical sample distribution (in this case 0.025) that the sample median is statistically different from the default ACR value. If the p-value was less than 0.025 there is evidence that the sample mean is different from the current default ACR value, indicating the current default ACR may not reflect the ACR costs of the PJM units that responded to the survey. If the p-value is greater than 0.025 then it cannot be proven that the mean of the sample is different from the current default ACR value.

Table 5: Survey Results

Technology Type	2011/2012 Mothball ACR	P value	Mothball Avoidable %	2011 Sample Median	Implied Mothball ACR 2011/2012	Implied Retirement ACR 2011/2012	Implied Mothball ACR 2016/2017	Implied Retirement ACR 2016/2017
CT - First & Second Generation Aero (P&W FT 4)	$25.69	**0.0001**	**75.2%**	**$26.13**	$26.13	**$34.76**	$31.91	**$42.45**
CT - Third Generation Aero (GE LM 6000)	$58.42	**0.0127**	**67.8%**	**$30.87**	$30.87	**$45.50**	$37.70	**$55.57**
Sub-Critical Coal	$178.24	**0.0195**	**90.2%**	**$136.91**	$136.91	**$151.76**	$167.21	**$185.35**
Super Critical Coal	$184.15	**0.0075**	**91.4%**	**$133.16**	$133.16	**$145.65**	$162.63	**$177.89**
CT - First & Second Generation Frame B	$25.38	0.8138	74.9%	Not Statistically Different	$23.51	$31.38	$29.78	$39.74
CT - Second Generation Frame E	$24.13	0.0824	74.7%	Not Statistically Different	$22.36	$29.92	$28.32	$37.90
Diesel	$27.49	**0.0262**	**78.7%**	Not Statistically Different	$25.46	$32.33	$32.26	$40.97
Oil or Gas Steam	$68.18	0.1344	82.1%	Not Statistically Different	$63.16	$76.90	$80.01	$97.41

From the above for combustion turbine Aero Derivatives, Sub Critical and Super-Critical coal, the sample median is statistically different from the default 2011/2012 values. This would indicate that the current default ACR values do not reflect the ACR costs reported by those PJM units that responded to the survey and indicates that the current ACR values may need to be updated to reflect this information.

The 2011/2012 default ACR values are not the same as the implied mothball as the implied mothball was tested at the inflation adjusted level. (See: Section VI Handy Whitman Index)

Table 6 reflects the information gathered for the mothball 2011/2011 ACR estimates and Table 7 reflects the retirement 2011/2012 ACR estimates. Both tables illustrate that the proposed PJM values are within the range of the PJM survey, Brattle derived values or values derived from the EIA study.

Table 6: Range of 2011/2012 mothball default ACR estimates

Current Default Category	Current 2011/2012 Mothball ACR Value	Proposed Default Category	Proposed 2011/2012 Mothball ACR Value	Mothball ACR Values Derived from PJM Sample	Mothball ACR Values Derived from Brattle Study	Mothball ACR Values Derived from EIA Study
CC - NUG Cogeneration Frame B or E Technology	$120.16	Combined Cycle (CC)	$29.58	N/A	$26.32	$29.12 - 29.58
CC - Three on One Frame E/Siemens Technology	$35.89					
CC - Three or More on One or More Frame F Technology	$27.98					
CC - Two on One Frame F Technology	$32.33					
CT - First & Second Generation Aero (P&W FT 4)	$25.69	Combustion Turbine (CT) Aero Derivative	$26.13	$26.13 - $30.87	N/A	N/A
CT - Third Generation Aero (GE LM 6000)	$58.42					
CT - Third Generation Aero (P&W FT-8 TwinPak)	$30.64					
CT - First & Second Generation Frame B	$25.38	Combustion Turbine (CT) Industrial Frame	$24.13	$22.36 - $23.51	$24.62	$13.35 - $14.96
CT - Second Generation Frame E	$24.13					
CT - Third Generation Frame F	$24.77					
Sub-Critical Coal	$178.24	Coal Fired	$136.91	$136.91 - $133.16	N/A	$77.84 - $94.37
Waste Coal - Large	$86.94					
Waste Coal - Small	$235.06					
Super Critical Coal	$184.15					
Diesel	$27.49	Diesel	$25.46	$25.46	N/A	N/A
Hydro	$74.24	Hydro	$68.78	N/A	N/A	$29.51
Oil and Gas Steam	$68.18	Oil and Gas Steam	$63.16	$63.16	N/A	N/A
Pumped Storage	$21.72	Pumped Storage	$20.12	N/A	N/A	$26.63

Table 7: Range of 2011/2012 retirement ACR estimates

Current Default Category	Current 2011/2012 Retirement ACR Value	Proposed Default Category	Proposed 2011/2012 Retirement ACR Value	Retirement ACR Values Derived from PJM Sample	Retirement ACR Values Derived from Brattle Study	Retirement ACR Values Derived from EIA Study
CC - NUG Cogeneration Frame B or E Technology	$161.45	Combined Cycle (CC)	$40.69	N/A	$37.33	$41.30 - $41.96
CC - Three on One Frame E/Siemens Technology	$48.60					
CC - Three or More on One or More Frame F Technology	$38.85					
CC - Two on One Frame F Technology	$45.85					
CT - First & Second Generation Aero (P&W FT 4)	$34.17	Combustion Turbine (CT) Aero Derivative	$37.18	$34.74 - $45.50	N/A	N/A
CT - Third Generation Aero (GE LM 6000)	$86.10					
CT - Third Generation Aero (P&W FT-8 TwinPak)	$45.17					
CT - First & Second Generation Frame B	$33.87	Combustion Turbine (CT) Industrial Frame	$33.04	$29.92 - $31.38	$35.47	$13.35 - $19.24
CT - Second Generation Frame E	$32.29					
CT - Third Generation Frame F	$35.68					
Sub-Critical Coal	$197.58	Coal Fired	$157.83	$145.65 - $151.76	N/A	$85.13 - $103.25
Waste Coal - Large	$105.02					
Waste Coal - Small	$284.70					
Super Critical Coal	$201.42					
Diesel	$34.91	Diesel	$32.33	$32.33	N/A	N/A
Hydro	$97.10	Hydro	$89.96	N/A	N/A	$38.58
Oil and Gas Steam	$83.01	Oil and Gas Steam	$76.90	$76.90	N/A	N/A
Pumped Storage	$30.50	Pumped Storage	$28.26	N/A	N/A	$37.50

Review by Proposed Category

Combined Cycle

Combined Cycle Category includes:

- CC - NUG Cogeneration Frame B or E Technology
- CC - Three on One Frame E/Siemens Technology
- CC - Three or More on One or More Frame F Technology
- CC - Two on One Frame F Technology

PJM's sample size was too small to disclose medians of the combined cycle sample. However information is available from other sources. Brattle's combined cycle implied mothball ACR estimate from fixed operation and maintenance expense was $32.16 per MW-day for 2016/2017, and EIA's implied mothball ACR estimate for advanced and conventional combined cycle units was $35.58-$36.15 per MW-day. PJM's proposed 2016/2017

mothball value is $36.13 per MW-day[34], which is in the range of the two study results and is the result of escalating $29.58 in 2011/2012, one of the t EIA derived values.

Brattle's combined cycle implied retirement ACR estimate from fixed operation and maintenance cost was $45.62 per MW-day for 2016/2017, and EIA's implied retirement ACR estimate for advanced and conventional combined cycles was $50.47-$51.27 per MW-day. PJM's proposed 2016/2017 retirement value is $49.69 per MW-day[35], which is in the range of the two study results.

Combustion Turbine Aero Derivative

Combustion turbine Aero Derivative category includes:

- CT - First & Second Generation Aero (P&W FT 4)
- CT - Third Generation Aero (GE LM 6000)
- CT - Third Generation Aero (P&W FT-8 TwinPak)

PJM's sample showed CT - First and Second Generation Aero (P&W FT 4) to be approximately $31.91 and for CT – Third Generation Aero (GE LM 6000) at $37.70 for a mothball 2016/2017 estimate. This puts the PJM mothball 2016/2017 estimate within the lower bound of that range at $31.91 per MW-day[36]. PJM's retirement estimate for CT Aero Derivative, modifying the mothball estimate to full retirement, is $45.41 per MW-day[37] in 2016/2017. This falls within the sample retirement ACR estimates of $42.45-$55.47 per MW-day.

Combustion Turbine Industrial

Combustion turbine Industrial Category includes:

- CT - First & Second Generation Frame B
- CT - Second Generation Frame E
- CT - Third Generation Frame F

PJM's sample showed no statistical difference from the default values for both Frame B and Frame E. This puts the PJM's sample estimate at $28.32 and $29.78 per MW-day for 2016/2017. The Brattle report's implied 2016/2017 mothball ACR for advanced combustion turbines was $30.08 per MW-day, and EIA's implied mothball 2016/2017 ACR for conventional combustion turbines was $18.28 per MW-day. This presents a range of $18.28 to $30.08 per MW-day; within which the PJM mothball 2016/2017 estimate of $29.47 per MW-day [38] fits. Retirement values for this

[34] This Combined Cycle value is escalated from 2011/2012 mothball estimate of $29.58 per MW-day.

[35] This Combined Cycle value is escalated from 2011/2012 retirement estimate of $40.69 per MW-day.

[36] This Combustion Turbine Aero Derivative value is escalated from 2011/2012 mothball estimate of $26.13 per MW-day.

[37] This Combustion Turbine Aero Derivative value is escalated from 2011/2012 retirement estimate of $37.18 per MW-day

[38] This Combustion Turbine Industrial value is escalated from 2011/2012 mothball estimate of $24.13 per MW-day

unit category range from EIA's 2016/2017 estimate for conventional combustion turbine at $24.48/MW-day to PJM's sample estimate for Frame E at $37.90 per MW-day up to the Brattle-derived estimate of $43.34 per MW-day. PJM's recommended estimate is $40.35 per MW-day[39] for 2016/2017 retirement ACR.

Coal-Fired Units

Coal-Fired Units Category includes:

- Sub-Critical Coal
- Waste Coal – Large
- Waste Coal – Small
- Super-Critical Coal

PJM was unable to get estimates for waste coal's default ACR values; these values are being rolled into a larger coal category and any waste coal unit with higher costs is able to provide a unit-specific calculation. PJM's sample of sub and super-critical units 2016/2017 mothball estimates were $167.21 and $162.63 per MW-day respectively. Estimates derived from the EIA study provided values for dual and single super-critical units at $95.120 – $115.31 per MW-day for the 2016/2017 ACR. At $167.12 per MW-day [40] for the 2016/2017 delivery year PJM's mothball ACR estimate is within the range of $94.80 to $167.63 per MW-day.

EIA's retirement ACR estimates for 2016/2017 were estimated at $104.07 – $126.16 per MW-day. PJM's sample of sub and super-critical units 2016/2017 retirement estimates were $177.89-$185.35 per MW-day respectively. The proposed PJM retirement value for coal fired units is $192.76 per MW-day[41], which is slightly higher than the range.

Diesel

PJM is not proposing a change to the diesel ACR as our sample did not show that the value was statistically different from the default. PJM proposes escalating the 2011/2012 delivery year of $25.46 per MW-day (adjusted for actual inflation) to $31.09 per MW-day in 2016/2017. PJM proposes a 2011/2012 retirement ACR of $32.33 per MW-day and $39.49 per MW-day for 2016/2017.

Hydro

ACR estimates derived from the EIA study put hydro mothball ACR for 2016/2017 at $35.94 per MW-day. Although PJM's sample was too small to derive new values for hydro ACR, PJM believes these initial estimates should be adjusted for inflation. The hydro mothball value for 2016/2017 derived from the EIA study is $36.06 per MW-day. PJM is proposing an inflation adjustment to the mothball hydro ACR value for the 2011/2012 delivery year to $68.78 per MW-day,[42] which escalates to $84.00 per MW-day in 2016/2017. The hydro retirement value for 2016/2017

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[39] This Combustion Turbine Industrial value is escalated from 2011/2012 retirement estimate of $33.04 per MW-day

[40] This Coal Unit value is escalated from 2011/2012 mothball estimate of $136.91 per MW-day.

[41] [41] This Coal Unit value is escalated from 2011/2012 retirement estimate of $157.83 per MW-day.

[42] This adjustment is explained in the part of the paper about Handy-Whitman.

derived from the EIA study is $47.14 per MW-day; however, it is PJM's opinion that the hydro retirement ACR values should remain the same (adjusted for inflation) at $89.96 per MW-day for 2011/2012 and $109.86 per MW-day for 2016/2017.

Oil and Gas Steam

PJM's sample showed that current ACR values are not statistically different; therefore, PJM proposes keeping the 2011/2012 at the default level of $63.16 and $77.14 per MW-day in 2016/2017. The proposed retirement ACR values for oil and gas steam are $76.90 per MW-day for 2011/2012 and $93.91 per MW-day for 2016/2017.

Pumped Storage

ACR estimates derived from the EIA study put the pumped storage mothball ACR in 2016/2017 at $32.54 and retirement ACR at $45.70 per MW-day. PJM is proposing an inflation adjustment to the pumped storage ACR value for the 2011/2012 delivery year to $20.12 escalating to 2016/2017 mothball ACR value to $24.26. Although PJM's sample was too small to derive new values for the pumped storage ACR, PJM believes these initial estimates should be adjusted for inflation.[43] PJM proposes a retirement ACR for 2011/2012 of $28.26 MW-day and in 2016/2017 of $34.51/MW-day.

[43] This adjustment is explained in the part of the paper about Handy-Whitman.

VI. Handy-Whitman Index

Currently, PJM uses the 10-year average of the "Total Steam Production Plant" from the annual July bulletin of the *Handy-Whitman Index of Public Utility Construction Costs*. Using the 10-year average to estimate future years is a good proxy for inflation; however, the ACR values should be corrected for inflation as the Handy-Whitman Index is updated.

The "Handy-Whitman Index of Public Utility Construction Costs is a widely used utility cost index that has been published since 1924."[44] In addition to being a commonly used standard by the utility industry, because it was not developed for RPM, it is not biased by any particular market participant. The FERC expressly approved the use of Handy-Whitman Index finding it "reasonable to rely on Handy-Whitman Index as it is an index specifically tailored to the utility industry."[45] Within PJM stakeholder process, "… the CMEC (Capacity Market Evolution Committee) agreed to annual increases in those values based on a ten year annual average rate of change in the applicable Handy-Whitman Index of Public Utility Construction Costs. The CMEC also agreed that the indexing approach should be reviewed after it has been in place for three Delivery years."[46]

Applying the most recent 10-year average Handy-Whitman Index to previously calculated default ACR values without recalculating the base values using the most recent Handy-Whitman Index can lead to significant biases either upward or downward that can compound over time. The issue was explained in the Market Monitor's *Analysis of the 2013/2014 RPM Base Residual Auction Revised and Updated*. However the tariff does not provide for adjusting base values prior to applying the 10-year average Handy-Whitman Index.

According to the Market Monitor's *Analysis of the 2013/2014 RPM Base Residual Auction Revised and Updated*:

> PJM's default values for 2013/2014 are overstated because PJM's approach used the annual average rate of change in the Handy-Whitman Index for the ten year period from 1999 through 2008. This annual average rate of change was used to calculate the default ACR values for each year from 2009/2010 through 2012/2013. However, at the time of PJM's calculation, more current Handy-Whitman Index values were available.
>
> In order to have an accurate calculation of the 2013/2014 ACR default values, the base year values for the delivery years 2009/2010 through 2012/2013 must be calculated using the most current actual Handy-Whitman Index data rather than relying on outdated data. Unless this approach is taken each year,

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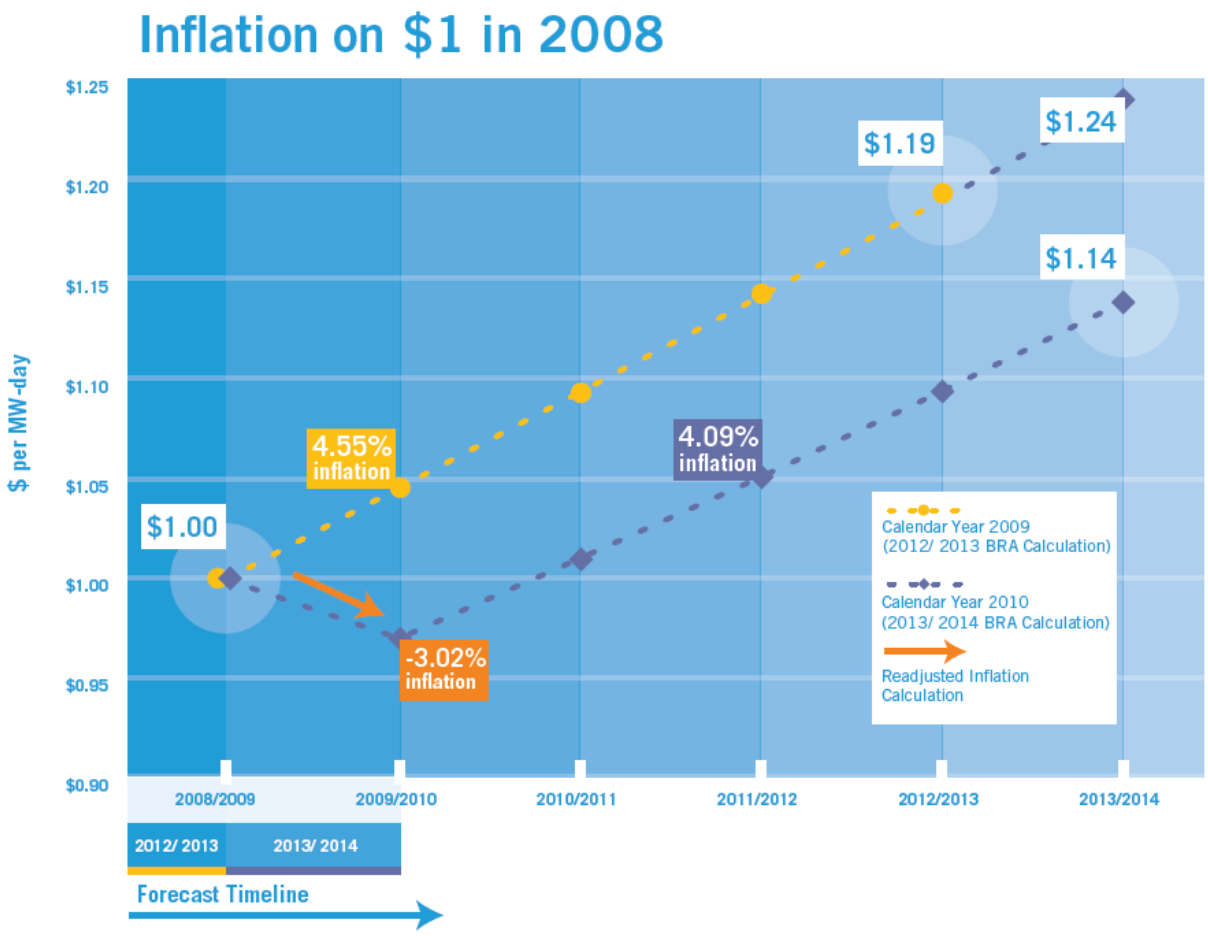
[44] Answer of PJM Interconnection, LLC to Comments and Protests, Docket No. ER09-412-006
Docket No. ER09-1673-000 p3 10/7/2009 http://pjm.com/~/media/documents/ferc/2009-filings/20091007-er09-412-006.ashx

[45] NYISO 122 FERC 61,064 at pp 11 http://www.ferc.gov/whats-new/comm-meet/2008/121808/E-33.pdf

[46] PJM filing ER-09-1673-000 http://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=12131893

the estimated values will use fewer and fewer years of actual Handy-Whitman data, and the result will potentially diverge farther each year from an estimate calculated using the actual historical Handy-Whitman Index data. The method used by PJM may result in either an overstatement or an understatement of the appropriate value, depending on the relationship between the actual Handy-Whitman Index value and the estimate.

Figure 1: Explanation of adjustment for actual inflation



For example, assume in the 2008/2009 delivery year (base year) that ACR is $1 per MW-day. For the 2012/2013 BRA to be held in May 2009, the inflation as measured by the 10-year average Handy-Whitman Index (HWI) for the period July 1999- July 2008 was 4.55 percent. The 10-year average HWI is applied to the ACR of $1 per MW-day in 2008/2009 to derive the ACR applicable for the 2012/2013 Delivery Year. The 2012/2013 ACR is then equal to the 2008/2009 ACR of $1/MW-day multiplied by one plus the HWI adjustment, four times. Working through this step by step, the estimate for 2009/2010 taken from the $1 in 2008/2009 would be $1.05 per MW-day. Then, to get to the 2009/2010 estimated value, the estimated $1.05 should be escalated again by 1.0455, which produces a value of $1.09 per MW-day. Taking the $1.09 value for 2010/2011 and escalating by 1.0445 produces $1.14 per MW-day. Finally, taking $1.14 for 2010/2011 and escalating by 1.0445 to 2011/2012 value gives us $1.19 per MW-day as the

estimate for 2012/2013 based on the 10-year average and all available information for the 2012/2013 BRA in May 2009. In other words, applying the 4.55 percent escalation rate from the most recent calendar year prior to the Base Residual Auction held for the delivery year three years forward means that an ACR of $1 per MW-day in 2008 is escalated to $1.19 per MW-day for 2012/2013[47].

For the period July 2008 to July 2009, the HWI shows, the actual inflation was negative (-3.02 percent), meaning prices fell during this period. The resulting updated 10-year average HWI adjustment from July 2000 to July 2009 is 4.09 percent. The current tariff methodology would then multiply the $1.19/MW-day ACR value for 2012/2013 by one plus the updated 10-year average HWI (1.0409) to get a 2013/2014 ACR value of $1.24/MW-day.

The current tariff methodology does not account for the fact that the 2012/2013 value calculated for the previous BRA assumed a 4.55 percent inflation rate the first year (2009/2010 Delivery Year), when the actual inflation rate for that year was 7.75 percent lower than the original estimate. If this isn't taken into account for the 2013/2014 BRA in May 2010 when estimating the ACR, the error in the forecasted inflation value will never be addressed. However, if the ACR values are updated to include actual realizations of inflation as described below, then ACR values will not be over-estimated or under-estimated.

Going back to the base year ACR value of $1/MW-day in 2008/2009, and multiply the $1/MW-day by one plus the first year inflation of -3.02 percent, the 2009/2010 ACR value is then $0.97/MW-day. To finish the derivation of the 2013/2014 ACR to be used in the May 2010 BRA, multiply the 2009/2010 ACR of $0.97/MW-day by one plus the 10-year average HWI adjustment, four times. The 2010/2011 estimated value is then $0.97/MW-day multiplied by 1.0409 or $1.01/MW-day. The estimated value for 2011/2012 is $1.01/MW-day escalated again by 1.0409, which produces a value of $1.05 per MW-day. The 2012/2013 value is $1.09/MW-day from escalating the 2011/2012 by 1.0409. Finally, taking $1.09/MW-day value for 2012/2013 and escalating by 1.0409 gives provides the 2013/2014 ACR value of $1.14/MW-day. Adjusting the ACR values for 2009/2010 in this example for actual, realized inflation before escalation mitigates the problem of over or under estimating inflation through using the 10-year average value as an estimate. Using the actual rate of change when applying the updated 10-year average Handy-Whitman Index of 4.09 percent, results in an ACR of $1.09 per MW-day for 2012/2013, compared to $1.19 per MW-day in the prior calculation. The first 2008/2009 value would be adjusted for actual inflation in 2009/2010 to give a starting estimate of $0.97 per MW-day for the 2009/2010 delivery year and escalating that value by the new 10-year average of 4.09 percent. The purpose of the recalculation using the most recent Handy-Whitman Index is to ensure that the base values are accurate prior to applying the estimated escalation and not to modify default ACR values for prior RPM auctions.

This estimation error is not just biased downward. For example, if 2009 actual inflation was greater than the 10-year average, then using the current escalation method would underestimate future default avoidable costs. In this

[47] In other words, 1.0445 raised to the 4th power is 1.194803.

scenario, the default ACR rates would not increase with the same magnitude as actual costs, and the future actual costs would be less than the projected default ACR.

It is imperative to get the correct future values for default avoidable costs. If the costs are incorrect the resulting Market Seller Offer Caps using default ACR in RPM will not be in alignment with the actual going forward costs for generation resources in PJM. If the default values are too high this may result in RPM prices that are higher than necessary to ensure resource adequacy. If the default values are too low, generation resources at least have the option to submit unit specific ACR values to reflect their actual costs to go forward and continue in commercial operation. Further, for the 2016/2017 values proposed in this paper, they should not be final until the 2012 Handy-Whitman Index is available and the reported 2011/2012 ACR values have been adjusted.

Review Handy-Whitman Index and consider Producer Price Index for electric generation

PJM recommends a review of Handy- Whitman index as well as other possible indices that could be used in RPM. The Handy-Whitman Index may not be the best proxy for inflation. From 2005 to 2012 the Handy-Whitman Index for 'Other Plant Expenses' has never decreased, even throughout the recession starting in December 2007 and ending in June 2009[48]. "Other Steam Plant" did show a negative inflation estimate in 2009 of -3 percent.

There may be more accurate estimates for the inflation of ACR. In 2005 the Bureau of Labor Statistics (BLS) started releasing "the Producer Price Index (PPI) introduced data for … the Electric Power Generation." The BLS produces its indices monthly within a detailed report. The index for Electric Power Generation "measures price changes for the initial commercial transaction received by power generating establishments. This industry comprises facilities that convert other forms of energy, such as water power, fossil fuels, nuclear power, and solar power, into electric energy for sale to electric power transmission and distribution systems." As compared to the Handy-Whitman Index, the PPI is publicly available and is more general in scope. However, the Handy-Whitman Index is considered the industry standard, and there is a cost to changing from Handy-Whitman to PPI because of updates made to systems and documentation as well time spent to educate market participants during a transition. PJM recommends further investigation into the most appropriate inflation index to use in RPM.

VII. Conclusion

Questions to Answer

Are the default ACR values in the OATT appropriate?

PJM concludes that some of the ACR values for 2011/2012 are adequate; however, others may need to be updated based on the information reviewed in this paper. The estimates and how they are derived for each unit technology type can be found in Review by Proposed Category

[48] CNN/ National Bureau of Economic Research http://money.cnn.com/2010/09/20/news/economy/recession_over/index.htm

Is the escalation method appropriate?

The escalation method is appropriate with one caveat – escalation of the 10-year average without ever adjusting for actual values may over inflate or deflate the values of the default ACR. PJM recommends using the most up-to-date actual information instead of using estimation methods for future inflation.

What are the best values to use in future RPM Auctions?

PJM recommends updating the values in Table 8 based on a review of similar studies and a survey of PJM member's ACR costs conducted by PJM staff. Additionally, as depicted in Table 8, PJM proposes the default categories be changed to be more inclusive and not put any undue administrative burden on any particular unit type not defined in previous default categories. Based on this review of the data, the breakout of these unit types seems less necessary now, and, as new unit types emerge, they are more likely to fall into the proposed defaults.

Table 8: Proposed default ACR values

Current Default Category	Current 2011/2012 Mothball ACR Value	Current 2011/2012 Retirement ACR Value	Proposed Default Category	Proposed 2011/2012 Mothball ACR Value	Proposed 2011/2012 Retirement ACR Value	Proposed 2016/2017 Mothball ACR Value	Proposed 2016/2017 Retirement ACR Value
CC - NUG Cogeneration Frame B or E Technology	$120.16	$161.45	Combined Cycle (CC)	$29.58	$40.69	$36.13	$49.69
CC - Three on One Frame E/Siemens Technology	$35.89	$48.60					
CC - Three or More on One or More Frame F Technology	$27.98	$38.85					
CC - Two on One Frame F Technology	$32.33	$45.85					
CT - First & Second Generation Aero (P&W FT 4)	$25.69	$34.17	Combustion Turbine (CT) Aero Derivative	$26.13	$37.18	$31.91	$45.41
CT - Third Generation Aero (GE LM 6000)	$58.42	$86.10					
CT - Third Generation Aero (P&W FT-8 TwinPak)	$30.64	$45.17					
CT - First & Second Generation Frame B	$25.38	$33.87	Combustion Turbine (CT) Industrial Frame	$24.13	$33.04	$29.47	$40.35
CT - Second Generation Frame E	$24.13	$32.29					
CT - Third Generation Frame F	$24.77	$35.68					
Sub-Critical Coal	$178.24	$197.58	Coal Fired	$136.91	$157.83	$167.21	$192.76
Waste Coal - Large	$86.94	$105.02					
Waste Coal - Small	$235.06	$284.70					
Super Critical Coal	$184.15	$201.42					
Diesel	$27.49	$34.91	Diesel	$25.46	$32.33	$31.09	$39.49
Hydro	$74.24	$97.10	Hydro	$68.78	$89.96	$84.00	$109.86
Oil and Gas Steam	$68.18	$83.01	Oil and Gas Steam	$63.16	$76.90	$77.14	$93.91
Pumped Storage	$21.72	$30.50	Pumped Storage	$20.12	$28.26	$24.57	$34.51

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[49] Further for the 2016/2017 values proposed by this paper, they should not be final until the 2012 HWI is available and the reported 2011/2012 ACR values have been adjusted.

VIII. Appendix A: Form used by PJM for 2012 Triennial ACR Survey

Unit and Technology Data - Confidential

General Unit Data		Hydro and Pump Storage Hydro	
eRPM ID		Turbine OEM	
Current Default ACR Technology Classification		Number of Turbines	
Plant Commercial Operation Year		Turbine Type	
Net Plant Heat Rate (BTU/kWh) (HHV)		Turbine Capacity (MW)	
ICAP (MW)		Pump OEM	
Unit Type		Black Start Capable	

Combustion Turbine, Diesel or Combined Cycle Technical Information	Boiler - Steam Turbine Plant Technical Information
Primary Fuel	Primary Fuel
Back Up Fuel	Back Up Fuel
On Site Natural Gas Compression	Number of Boilers
CT or Diesel Original Equipment Manufacturer (OEM)	Boiler OEM
CT or Diesel Model	Boiler Design Configuration
Total Combustion Turbine or Diesel Rating at ISO (MW)	Supercritical/Subcritical
Number of Combustion Turbine or Diesel Units	Fuel Input at Rated Capacity (MMBTU/Hr) (HHV)
Simple Cycle Bypass Stack	Number of STGs
Steam Turbine Generator (STG) OEM	STG OEM
Total STG Capacity (MW)	STG Capacity (MW)
Number of STG	Primary Boiler NOx Control
Per HRSG Duct Burner Capacity (MMBTU/Hr) (HHV)	Secondary Boiler NOx Control
Combustion Turbine/Diesel NOx Control Type	Primary Particulate Control
Combustion Turbine/Diesel Exhaust NOx Control	Secondary Particulate Control
Combustion Turbine/Diesel CO Control	Tertiary Particulate Control
Number of HRSG Pressures	SO2 Control
Co-Generation	CO Control
Condenser Cooling System	Mercury Control
Turbine Inlet Air Cooling Technology (TIC)	Co-Generation
Black Start Capable	Condenser Cooling System
	Black Start Capable

Cost Data - Confidential

Please enter unit level cost data if available; if not then put in plant level data and a unit level allocation percent

Unit level allocation %	100%	
Operations and Maintenance Labor (AOML)	2011	% Avoidable
Operations and Maintenance		
Other		
Total	$ -	$ -
Administrative Expense (AAE)	2011	% Avoidable
Administrative Salaries		
Employee Expenses		
Environmental Fees		
Safety & Operator Training		
Office Supplies		
Communications		
Annual Plant Tests, Inspections & Analysis		
Other		
Total	$ -	$ -
Maintenance Expense (AME) (Non-CDS)	2011	% Avoidable
Maintenance Parts		
Maintenance Contract Services		
Chemicals & Materials Consumed		
Rented Equipment		
Other		
Total	$ -	$ -
Variable Expense (AVE) (Non-CDTF)	2011	% Avoidable
Water Treatment Chemicals		
Lubricants		
Water (Not for Power Generation)		
Gas (Not for Power Generation)		
Electric (Not for Power Generation)		
Waste Water Treatment		
Other		
Total	$ -	$ -

Carrying Charges (ACC)	2011	% Avoidable
Spare Parts Inventory		
Fuel Inventory		
Other Inventory		
Total Inventory	$ -	$ -
Carrying Cost Rate (%)		
Total Carrying Cost	$	-
Corporate Level Expenses (ACLE)	2011	% Avoidable
Legal Services		
Environmental Reporting		
Procurement Expenses		
Corporate Overhead		
Other		
Total	$ -	$ -
Taxes Fees and Insurance (ATFI)	2011	% Avoidable
Annual Insurance Premium		
Permits and Licensing Fees		
Site Security and Utilities		
Annual Property Tax Payment		
Other		
Total	$ -	$ -