

# The Prediction and Optimization of Smart Energy Usage through Machine Learning Recommendations

MSc Research Project Data Analytics

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#### National College of Ireland Project Submission Sheet School of Computing



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Date:	21st September 2021

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## The Prediction and Optimization of Smart Energy Usage through Machine Learning Recommendations

# Mark McGrane x19140606

## 1 Hardware Requirements and Technologies Used

Before implementing this project, please ensure that your local machine has the minimum memory requirements and operating specifications as detailed in Table 1. It may be necessary to zoom into 125% or higher to see the definition of some of the screenshots. If the system requirements and software specified within this section are already installed on the local machine, it is possible to move to Section 7

Device Processor	AMD Ryzen 7 3700U with Radeon Vega Mobile Gfx 2.30 GHz
Installed RAM	16.0 GB (13.9 GB usable)
System Type	64-bit operating system, x64-based processor
Windows Edition	Windows 10 Home
Windows Version	20H2
Windows Operating System Build	19042.1165
Windows Experience	Windows Feature Experience Pack 120.2212.3530.0

Table 1:	Device	and (	Operating	Specificat	ions
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The practical element of the report will use various technologies and programming languages. There will be the need to download and configure these on a local system to display output. The following will need to be implemented.

• R

- R Studio
- PostgreSQL
- Anaconda and Jupyter Notebook
- Tensorflow and Keras

## 2 R

The language R is used for data cleaning, analysis and statistical generation. Down-loading and installation is demonstrated in the following two chapters.

#### 2.1 Downloading R from www

Figures 1-4 demonstrate how to download R from the internet. Open any web browser and navigate to www.r-project.org. Once there, click on the "to download R" hyperlink, which should take you to the web address cran.r-project.org/mirrors.html. Please see Figure 1 and Figure 2. The remainder of the steps are based on the assumption that the download and installation are to a windows machine described above in Section 1.

The hyperlink "Download R for Windows" should be clicked and then saved in the normal folder used for downloads on the local device. Please see figures Figure 3 and Figure 4.



Figure 1

> C 88   🔒 cran.r-project.org/mirrors.html	
21 Iteration   R for	
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https://cran.um.ac.in/	Ferdowsi Universi
l h <u>ttps://flp.heanet.ie/mirrors/cran.r-project.org</u> /	HEAnet,Dublin
https://cran.mirror.parr.it/CRAN_ https://cran.stat.unipd.it/	Garr Mirror, Milar University of Padr

Figure 2

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<b>5</b>	1 chromedriver	30/11/2020 17:55	Application	9,962 KB	
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Atwork	30009-64bit_Win7_Win8_Win81_Win10_R282	03/07/2020 21:41	Application	258,227 KB	
-	KodakPrinterDriver	19/06/2020 17:12	Application	9,769 KB	
	5 ClickCharts	30/05/2020 14:05	Application	988 KB	
	DriverEasy_Setup	26/05/2020 21:20	Application	4,966 KB	
	👧 Bandicamp	26/04/2020 20:45	Application	19,246 KB	
	🖏 Zotero	26/04/2020 15:44	Application	41,500 KB	
	Zoominstaller	30/03/2020 15:55	Application	11,034 KB	
	iii Microsoft Teams	18/03/2020 19:33	Application	97,545 KB	
	BlueStacks	15/03/2020 02:58	Application	964 KB	
	😵 Laytex	09/03/2020 19:23	Application	238,529 KB	
	Eclipse	27/02/2020 20:30	Application	53,538 KB	
	🍓 Rapid Miner Studio	26/02/2020 20:01	Application	251,230 KB	
	WindleForPC	13/02/2020 19:50	Application	55,257 KB	
	Kaspersky	18/01/2020 10:36	Application	2,745 KB	
	How TV Player	17/01/2020 22:19	Application	48,803 KB	
	🔁 FileZilla	17/01/2020 18:10	Application	7,814 KB	
	📓 JDK 11	27/11/2019 20:47	Application	155,021 KB	
	骗 JavaSetup8	26/11/2019 21:29	Application	2.019 KB	
File name: RSt	udio-1.4.1106				
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Figure 3

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ge clements (D.)	.ipynb_checkpoints	24/07/2021 10:46	File folder	
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Save as type: Apr	lication			

Figure 4

### 2.2 Installing R locally

Once downloaded entirely, double click on the application to begin the installation process, as shown in Figure 5. Figure 6 shows how to select an alternative file path to install the source files if that is required. Unless specifically mentioned, the default path is used to install all software applications within this project.



Figure 5

👸 Setup - R for Windows 4.1.1 — 🗆 🗙
Select Destination Location Where should R for Windows 4.1.1 be installed?
Setup will install R for Windows 4.1.1 into the following folder.
To continue, dick Next. If you would like to select a different folder, dick Browse.           C:\Program Files\R\R-4.1.1         Browse
At least 2.5 MB of free disk space is required.
< Back Next > Cancel

Figure 6

Figures Figure 7, Figure 8, Figure 9, and Figure 10 demonstrate the last steps of the implantation. If the four options are not checked as demonstrated in Figure 7, manually select them before continuing. The accepted defaults were used as shown in Figure 8. Whilst a customized startup is a viable option; it is not advised as it deviates from the steps taken in the original implantation. Figure 9 and Figure 10 can be customized as desired. Even though a desktop shortcut and quick launch shortcut were originally chosen, selecting these should not impact results.

🔂 Setup - R for Windows 4.1.1	-		Х
Select Components Which components should be installed?		(	R
Select the components you want to install; clear the componen install. Click Next when you are ready to continue.	ts you do no	t want to	
User installation		~	
Core Files		90.7 MB	]
32-bit Files		50.9 MB	
64-bit Files		57.8 MB	
Message translations		8.8 MB	
Current selection requires at least 210.3 MB of disk space.		]	]
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Figure 7

舅 Setup - R for Windows 4.1.1	-		×
Startup options Do you want to customize the startup options?			R
Please specify yes or no, then click Next. O Yes (customized startup) O No (accept defaults)			
< Back N	lext >	Cano	el

Figure 8



Figure 9

Select Additional Tasks Which additional tasks should be performed?			R
Select the additional tasks you would like Setup to perform v Windows 4.1.1, then click Next.	while installing F	R for	
Additional shortcuts:			
Create a desktop shortcut			
Create a Quick Launch shortcut			
Registry entries:			
Save version number in registry			
Associate R with .RData files			
< Pade	Nevts		ncel
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Figure 10

## 3 R Studio

#### 3.1 Downloading R Studio from www

R Studio is an open-source Integrated Development Environment (IDE) that provides a front end client to develop and run R code. R Studio can be downloaded from www.rstudio.com/produts/rstudio/downloads. Several paid subscription products can be used, but the free version highlighted in Figure 11 was more than capable of the project requirements. There are several potential downloads for the system in question, as demonstrated in figure Figure 12. Please download the most applicable to you. The file should be saved in the standard folder used for downloads on the local device, as shown in Figure 13.



Figure 11



Figure 12

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📻 Pictures 🛛 🖈	sfdx-windows-amd64	02/01/2021 20:28	Application	29.952 KB	
👝 OneDrive - Personal	× A long time and (54)				
This DC	BBDesktonSetun	30/12/2020 16-20	Application	200 500 KB	
	Chromedriver	30/11/2020 17:55	Application	9.962 KB	
Elements (D:)	Steam Setun	09/10/2020 20:18	Application	1 537 KB	
> Videos	The Debut	30/07/2020 14:44	Application	2.550 KB	
	3 0009-64bit Win7 Win8 Win81 Win10 R282	03/07/2020 21:41	Application	258.227 KB	
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	DriverEasy Setup	26/05/2020 21:20	Application	4.966 KB	
	Sandicamp	26/04/2020 20:45	Application	19,246 KB	
	2 Zotero	26/04/2020 15:44	Application	41,500 KB	
	Zoominstaller	30/03/2020 15:55	Application	11,034 KB	
	i Microsoft Teams	18/03/2020 19:33	Application	97,545 KB	
	BlueStacks	15/03/2020 02:58	Application	964 KB	
	😵 Laytex	09/03/2020 19:23	Application	238,529 KB	
	🚯 Eclipse	27/02/2020 20:30	Application	53,538 KB	
	🍓 Rapid Miner Studio	26/02/2020 20:01	Application	251,230 KB	
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	🌒 Kaspersky	18/01/2020 10:36	Application	2,745 KB	
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	🔁 FileZilla	17/01/2020 18:10	Application	7,814 KB	
	🚳 JDK 11	27/11/2019 20:47	Application	155,021 KB	
	🔹 JavaSetuo8	26/11/2019 21:29	Application	2.019 KB	
File name: RStud	fio-1.4.1106				
Save as type: Applic	ration				

Figure 13

#### 3.2 Installing R Studio locally

Once downloaded entirely, double click on the application to begin the installation process, as shown in Figure 14. Figure 15 and Figure 16 shows how to select an alternative file path to install the source files or rename the start menu option if required. Once again, it is noted that the default options are used for this installation. The remainder of the wizard completes the installation. Nothing was changed from the default from this juncture onwards.

in to Quick Copy Paste Paste	path Move C shortcut to " t	opy OV	New item •	Properties	Select all	n
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$\leftarrow$ $\rightarrow$ $\land$ $\uparrow$ $\downarrow$ $\rightarrow$ This PC $\rightarrow$ 1	Windows (C:) > User	s > mmcgr > Downlo	oads >	v	P Search D	ownloads
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Figure 14

🌍 RStudio Setup			-	□ X
	Choose Install Choose the fold	Location er in which to in	stall RStudio.	
Setup will install RStudio and select another folder	in the following folde r. Click Next to contir	r. To install in a ue.	different folder, d	ick Browse
Destination Folder	tudio		Bro	wse
Space required: 903.0 M Space available: 264.4 G	B			
Nullsoft Install System v3.00	5.1	< Back	Next >	Cancel

Figure 15



Figure 16

The following file can now be run from within the R Studio application.

• Phase1-DataCleaning

## 4 PostgreSQL Database

PostgreSQL is a reliable, efficient and robust relational database model which is also open source.

#### 4.1 Downloading PostgreSQL Database from www

Open any web browser and navigate to www.postgresql.org/download. Once there, select the correct operating system, in this case, Windows, as seen in Figure 17. Next, the browser should redirect to www.postgresql.org/download/windows where the "download the installer" link must be selected as seen in Figure 18. Next, select the most recent version to download from the server, as shown in Figure 19. Finally, the file should be saved in the standard folder used for downloads on the local device, as shown in Figure 20.



Figure 17



Figure 18

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		Post	greSQL	Datab	ase Dow	nload			
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12.7		N/A	N/A		Download	Dov	inload		N/A
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Figure 19

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- Pictures	📷 Recurva	26/11/2015 20:04	Application	4,32
Videos	🏶 Notepad++	26/11/2015 20:06	Application	4,00
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Windows (C:)	🛐 Netgear Network Card	14/06/2018 20:46	Application	38,51
🎒 Network 🗸 🗸	<			
File name: post	gresql-13.3-2-windows-x64			
Save as type: Appli	cation			

Figure 20

#### 4.2 Installing PostgreSQL Database locally

Once downloaded entirely, double click on the application to begin the installation process, as shown in Figure 21. Once again, the default path is used for this installation, as demonstrated in Figure 22. All four are selected when selecting components to install as part of the installation, as shown in Figure 23.



Figure 21

			1
Installation Direct	ory		
Please specify the dir	ectory where PostgreSQL will be installed		
Installation Directory	C:\Program Files\PostgreSQL\13		

Figure 22

Setup	- 🗆 X
Select Components	
Select the components you want to install; or you are ready to continue.	dear the components you do not want to install. Click Next when
전 PostgreSQL Server 전 pgAdmin 4 전 Stack Builder 전 Command Line Tools	Click on a component to get a detailed description
VMware InstallBuilder	<back next=""> Cancel</back>

Figure 23

#### 4.3 Configuring PostgreSQL Database locally

Unlike other software installations within the project, the configuration is needed once PostgreSQL is downloaded and installed locally. First, the password needs to be set, as shown in Figure 24. Please note the sensitivity of the case. There is no password reset option; it is advisable to make a separate password record once it is created or keep it to DataAnalytics as demonstrated. Next, the server will "listen" for communications on a dedicated port number. Port 5432 is advised as the port to declare, as is shown in Figure 25. Finally, the relevant locale details are set, as shown in Figure 26. For this project, it is was decided not to launch stack builder upon completion of the configuration. Therefore, please ensure this box is not ticked, as shown in Figure 27, before clicking the "finish" button.

				_	□ x
Password					
Please provide a p	assword for the databas	e superuser (pos	itgres).		
Password	•••••				
Retype password	•••••			Data	Analytics
Mware InstallBuilder			< Back	Next >	Cancel

Figure 24

👏 Setup			_	□ X
Port				
Please select the port number the server	should listen on.			
Port 5432				
Mware InstallBuilder		< Pade	Nexts	Cancel

Figure 25



Figure 26



Figure 27

#### 4.4 Recap of the customised configuration

Please ensure the following configurations have been implemented precisely as outlined in the previous subsection 4.3 to avoid connectivity issues later within the project.

- Password: DataAnalytics (Case Sensitive)
- **Port:** 5432
- Locale: English, Ireland
- Launch Stack Builder At Exit?: Box Unchecked

## 5 Anaconda and Jupyter Notebook

The distribution and development of Python applications occur within Anaconda, which like R Studio, is an open-source environment that can be downloaded online.

Anaconda is downloaded from www.anaconda.com as shown in Figure 28. Also, similar to R Studio, there are many potential downloads (both free and subscription-based) for the system in question. Please download the most applicable to you. However, the individual open source edition highlighted is sufficient for the needs of this project. Once selected, the browser should lead you to www.anaconda.com/products/individual where the download can begin as shown in Figure 29 and Figure 30. The file should be saved in the standard folder used for downloads on the local device, as shown in Figure 31.

#### 5.1 Downloading Anaconda from www

< > C 88 www.anaconda.com		
21 Iteration   R for		
		roducts  Pricing Solution:
	Č	Individual Edition Open Source Distribution
	ſ	Commercial Edition Premium Package Repository
	้อ	Team Edition On-prem Package Repository
	\$	Enterprise Edition Full Data Science Platform
	a	Professional Services Data Experts Work Together

Figure 28



Figure 29



Figure 30

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🗸 🛊 Quick access	Name	Date modified	Туре	Size	
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	Netgear Network Card	14/06/2018 20:46	Application	38.510 KB	
	Sirefox	16/09/2018 22:52	Application	308 KB	
	Pyrbarm	27/06/2019 21:35	Application	241 555 KB	
	Python	27/06/2019 22:48	Application	24.829 KB	
	The Chrome	09/07/2019 22:24	Application	1.125 KB	
	TeamViewer	11/07/2019 18:37	Application	22.516 KB	
	ConvTrans	14/07/2019 21:19	Application	8.981 KB	
	Tupes	14/07/2019 21-22	Application	268.423 KB	
	Septinel	31/07/2019 20:58	Application	5,212 KB	
	Gittlub	18/09/2019 22:29	Application	89 298 KB	
	VirtualBox	18/09/2019 23:08	Application	166 464 KB	
	O Anaconda3	18/09/2019 23:19	Application	497 500 KB	
	77in	14/10/2019 17:05	Application	1.414 KB	
	CitrivBaraiyar	14/10/2019 10:07	Application	42 444 KB	
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File name: Anaco	onda3-2020.11-Windows-x86_64				
	-				

Figure 31

#### 5.2 Installing Anaconda locally

Once downloaded entirely, double click on the application to begin the installation process, as shown in Figure 32. The system on which you are installing Anaconda may have multiple users. It is the individual's choice to download for all users on the local device or just themselves, as shown in Figure 33. The primary installation of Anaconda for the project was just installed for the current user as recommended within the application. Figure 34 shows how to select an alternative file path to install the source files if that is required. Once again, it is noted that the default path is used for this installation.

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Documents	Results_111116 0 Anaconda3-2020.11-Windows-x86_64		08/05/2021 14:18 08/05/2021 15:40	Application Application	152,316 KB 468,161 KB
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Figure 32

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Install for: Just Me (recommended     All Users (requires admi	) n privileges)			
Anaconda, Inc. ————				

Figure 33

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Space required: 2.7GB						
Space available: 267.3GB						
Anaconda, Inc. ———						
		< Back	Next 3	>	Cano	el :

Figure 34

Not seen with R or R Studio, an advanced installation section is presented in Figure 35 with the facility to "Add Anaconda3 to my PATH environment variable" and "Register Anaconda3 as my default Python 3.8". It is anticipated that **diverging from the selection shown within the figure of option one unticked and option two ticked could impact the set-up within Anaconda.** The remainder of the wizard completes the installation. Nothing was changed from the default from this juncture onwards.



Figure 35

#### 5.3 Installing Jupyter Notebook

Once installed, Anaconda can be opened through the start menu or possibly a desktop shortcut if one was created as part of the set-up. Figure 36 outlines the final step necessary

to install Jupyter Notebook within the Anaconda environment. The wizard can be run with automatic default values and completes in a few short minutes.



Figure 36

The following files can now be run from within the Jupyter Notebook application.

- Phase2A-PipInstalls
- Phase2B-DataVisualisation
- Phase2C-DataSculpting
- Phase2D-TransferToPostgreSQL

## 6 Tensorflow and Keras

#### 6.1 Creation of new Anaconda Environment

The installation of Tensorflow and Keras for the Deep Learning model development will require additional configuration within Anaconda. As shown in Figure 37, this process starts with creating a new environment upon which these additional packages can be installed. As shown in Figure 38, it may be necessary to update your Anaconda Navigator if a more up to date version is available. This is always the preferred option to ensure you are running the most recent packages available within the application.



Figure 37

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Figure 38

#### 6.2 Installation of Tensorflow and Additional Packages

Once the new environment is created, it will be necessary to specifically install the packages used for the development of the Deep Learning Model. Figure 39 demonstrates how the Tensorflow package is installed within the new environment. For the purposes of the code run in the last file of the project, it will be necessary to repeat this final step to install the following packages.

- Matplotlib
- Pandas
- Seaborn
- Keras

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Figure 39

It is possible to verify these packages have been installed by checking the "Installed" section of the packages within the new environment as shown in Figure 40

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		🖬 tenso	flow-base 0 Tersoflow is a machine learning library, take package contains only tensorflow.	X 111
		a tenta	flow-estim () Tensoflow estimator is a tigh-level tensoflow validati greadly simplifies methine learning programming.	250
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Figure 40

The final steps are shown in Figure 41 and Figure 42. This involves launching and installing Jupyter Notebook as done previously in section 5.3. N.B. Jupyter must be installed and launched within the new environment which was just created.



Figure 41



Figure 42

## 7 Final Configuration Details

#### 7.1 Order Of Configuration

It is of vital importance that the installation of software is done in accordance to sections 2, 3, 4, 5, 6 and in the order specified. This will enable the R and Python scripts to behave with the consistency expected and experienced during the implementation and testing phase. Table 2 gives a breakdown of the milestones needed for each of the files to be executed.

Application	What Can Be Run Once Installed
R	
R Studio	Phase1-DataCleaning
PostgreSQL	
	Phase2A-PipInstalls
Anacanda	Phase2B-DataVisualisation
	Phase2C-PreProcessing
and	Phase 2D- $Transfer To Postgre SQL$
Jupyter	Phase 3A-Daily Energy Regress on Prediction Model-Random Forrest
	Phase 3B-Daily Energy Regression Prediction Model-Decision Trees
INOTEDOOK	Phase 3C-Daily Energy Regression Prediction Model-KNN
	Phase4A-RecommendationSystemDevelopment
	Phase4B-RecommendationSystemAnalysis
Tensorflow	Phage5 DeepNeuralNetworkPegeommender
and Keras	

#### Table 2: When Scripts Can Be Run

## 7.2 File Directories

2 local file paths will need to be set up on the local system to handle

- The input files are provided within the HUE Dataset. Once set up, please transfer the Residential 1-28.csv, Holidays.csv, WeatherYVR.csv and All-Residential.txt files there.
- The output files generated by the R and Python scripts as part of the project execution.

When implementing the project the directory C:\Users\mmcgr\OneDrive\Documents\ College2019\_2020\Semester4\ResearchProject\Development\InputFiles\OriginalHUE\_ Data was used for storing the input files (Residential 1-28.csv, Holidays.csv and WeatherYVR.csv)

The directory C:\Users\mmcgr\OneDrive\Documents\College2019\textunderscore2020\ Semester4\ResearchProject\Development\FilesForAnalysis was used for all files that are created, exported to and subsequently read back in from the project by the R and Python scripts.

## 7.3 Replacing Text Within Files

It will be necessary to make the following replacements in the files listed below to ensure automation.

#### • Phase1-DataCleaning

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/InputFiles/OriginalHUE\_Data" with the local directory where the input files are stored

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

#### • Phase2A-PipInstalls

No changes needed

#### • <u>Phase2B-DataVisualisation</u>

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

N.B. This will need to be done in 2 places within the file.

#### • Phase2C-PreProcessing

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

N.B. This will need to be done in 2 places within the file.

#### • Phase2D-TransferToPostgreSQL

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

#### $\bullet \ Phase 3 A\text{-} Daily Energy Regress on Prediction Model-Random For rest$

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

#### $\bullet \ Phase 3B\text{-}Daily Energy Regress on Prediction Model-Decision Trees$

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

#### • Phase3C-DailyEnergyRegressonPredictionModel-KNN

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

#### • Phase4A-RecommendationSystemDevelopment

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

N.B. This will need to be done in 3 places within the file.

#### • Phase4B-RecommendationSystemAnalysis

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

N.B. This will need to be done in 2 places within the file.

#### • Phase5-DeepNeuralNetworkRecommender

Replace "C:/Users/mmcgr/OneDrive/Documents/College2019\_2020/Semester4/ ResearchProject/Development/FilesForAnalysis" with the local directory where the output files will be created, exported to and subsequently read back in from.

N.B. This will need to be done in 2 places within the file.

#### 7.4 File Use

Table 3 gives a summary as to what files are used as inputs and are outputted as a result of each script. All input and output files are provided as part of the ICT Artefact Upload. Still, it is essential to note that the output files may be overridden as the scripts are executed.

Script	Input	Output
	CSV Files	CSV Files
	Residential-1.csv	
		energyUsageHistory
Phase1-DataCleaning	Residential-28.csv	WithWeather-V1.csv
	Weather-YVR.csv	
Phase2A-PipInstalls	—	—
	energyUsageHistory	energyUsageHistory
Phase2B-DataVisualisation	WithWeather-V1.csv	WithWeather-V2.csv
Physo2C ProProcessing	energyUsageHistory	energyUsageHistory
1 hase20-1 fel fotessing	WithWeather-V2.csv	WithWeather-V3.csv
Phago2D Transfor To Post gro SOI	energyUsageHistory	
Thase2D-Transfer for ostgresQL	WithWeather-V3.csv	
Phase3A-DailyEnergyRegressonPredictionModel-	energyUsageHistory	
RandomForrest	WithWeather-V3.csv	
Phase3B-DailyEnergyRegressonPredictionModel-	energyUsageHistory	
DecisionTrees	WithWeather-V3.csv	
Phase3C-DailyEnergyRegressonPredictionModel-	energyUsageHistory	
KNN	WithWeather-V3.csv	
		recommender
	energyUsageHistory	LogHistory.csv
Phase4A-RecommendationSystemDevelopment	WithWeather-V3 csv	
		recommenderSystem
		TestingResults.csv
	recommender	
	LogHistory.csv	
Phase4B-RecommendationSystemAnalysis		—
	recommenderSystem	
	TestingResults.csv	
	recommenderSystem	
	TestingResults.csv	
Phase5-DeepNeuralNetworkRecommender		—
	energyUsageHistory	
	WithWeather-V3.csv	

Table 3: How CSV Files Are Used Within Scripts

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