Design and Implementation of Pilot of a TVET Renewable Energy Course

DELIVERABLE #5 - TRAINING COURSES & PROFESSIONAL DEVELOPMENT

Session 51 (16 December 2022) – Term 2
C 22 – Energy Modeling and Analysis

From C22 Session 01 of 02:

1. Energy Efficiency Courses in 2 year RE EE Program
2. What “success” looks like at program completion
3. Content within context of other ITVET Belize Courses
4. Description of Course 22 in Term 2 of Year 1
5. Developing Course 22

From C22 Session 01 of 02:

C 22: Energy Modeling & Analysis

- Instructor Comments?
- Instructor Discussion?
- Instructor Suggestions?
- "Real World" Applications?

- Session 2 of 2 (December 16, 2022)
  - WUFI Software – Heat and Moisture Transiency
  - Passive House Planning Package (Software)
  - RetScreen (Software)
  - Examples of Assignment, Test, and Project text

From C22 Session 01 of 02:

1. Portions of Course 22 description
2. BuildingScience.com
3. WUFI Software Intro. – Heat and Moisture
4. Passive House Planning Package Introduction
5. RETScreen Introduction
6. ITVET Education License

1. Portion of Course 22 Description

2 Year (~32 Course) RE EE Program Overview

1st Year	Term 1	Communi-cations 1 Comm 1	Applied Math 1 Math 1	Intro to Ener. Sci. Ener Sci	PV Applications PV Appl	Elec. and Circuits 1 Elec. Cir. 1	Integrated Lab 1 Int Lab 1
	Term 2	Communi-cations 2 Comm 2	Energy Model. and Analysis Ener M A	Electricity and Circuits 2 Elec. Cir. 2	PV Grid Tied Design PV GT De		Integrated Lab 2 Int Lab 2
	Term 3	Communi-cations 3 Comm 3	Applied Math 2 Math 2	Solar Hot Water Systems Sol H W S	PV Solar Panel Installations PV Instal		Technical Drawing Tec Dwg
2nd Year	Term 4	Audits 1 – Customer Relations Audits 1	Energy Eff. Measure. & Verification E E M V	PV Stand Alone System Design PV SASD	PV Battery Based Installations PV Bat In		Sm. Wind Design & Operation Sm Wind
	Term 5	Projects and Comms 1 Pro Comm	Audits 2 – Load Analysis Audits 2	Econ Analysis of Energy Systems Econ A E S	Elec. Codes and Regulations Elec C A R		Project Planning Proj Plan
	Term 6	Adv. Energy System Design AES Des	Final Project (Classroom) Fin Proj	Bus. Operations & Entrepreneurs. Bus O & E	PV Sys. Maint. & Operation PV M & O		Final Proj. (Lab) Fin Pro

1. Portion of Course 22 Description

Term02: Course Calendar Year 1 Short Term (Jan – Mar) (5 Courses x 10 Weeks)				
240 Hours	Day 1 (Mon)	Day 2 (Tue)	Day 3 (Wed)	Day 4 (Thur)
8:10 – 8:50	C 21: Comm 2	C 22: Ener M A	C 21: Comm 2	C 22: Ener M A
8:50 – 9:30	C 21: Comm 2	C 22: Ener M A	C 21: Comm 2	C 22: Ener M A
9:30 – 10:10	C 21: Comm 2	C 22: Ener M A	C 21: Comm 2	C 22: Ener M A
10:10 – 10:25	15 minutes	15 minutes	15 minutes	15 minutes
10:25 – 11:05	C 23: Elec Cir 2	C 24: PV GT De	C 23: Elec Cir 2	C 25: PV GT De
11:05 – 11:45	C 23: Elec Cir 2	C 24: PV GT De	C 23: Elec Cir 2	C 25: PV GT De
11:45 – 13:00	Lunch & HR	Lunch & HR	Lunch & HR	Lunch & HR
13:00 – 13:40	Lab 1 (2:40)	Lab 1 (2:40)	C 25: PV GT De	C 23: Elec Cir 2
13:40-14:20	C 23: Elec Cir 2	C 24: PV GT De	C 25: PV GT De	C 23: Elec Cir 2
14:20 - 15:00	C23 = 6 Labs	C24 = 10 Labs	C 25: PV GT De	C 23: Elec Cir 2
15:00 - 15:40	C25 = 4 Labs	C25 = 0 Labs	C 25: PV GT De	C 22: Ener M A
C 21: Comm 2	40 hours	10 x 6 CP x 2/3	C 21: Communications 2 (LC 2)	
C 22: Ener M A	46.7 hours	10 x 7 CP x 2/3	C 22: Energy Modeling and Analysis (EE 3)	
C 23: Elec Cir 2	62.7 hours	((10x7 CP) + (6 x 4 LP)) x 2/3	C23: Electricity and Circuits 2 (AS 2) Labs (6 x 4 periods) on Weeks 3, 4, 5, 7, 8, 9	
C 24: PV GT De	80 hours	((10x8 CP) + (10 x 4 LP)) x 2/3	C 24: Grid tied PV Design (PV2) Labs (10 x 4 periods) on Weeks 1 – 10	
C25: Int Lab 2	10.7 hours	(4x4 LP) x 2/3	C 25: Integrated Laboratory 2 (NL 2) Labs (4 x 4 periods) on Weeks 1, 2, 6, 10)	

1. Portion of Course 22 Description

- Energy Use, Modeling and Analysis (Term 2, Year 1)
- 46.7 Classroom Hours as 10 weeks x 7 periods / week
- 3 periods Tue. am and 4 Periods Thursday am + pm

<u>Marking Breakdown</u>

20% Individual Tests

30% Individual Projects

40% Group Projects

10% Employability Skills



1. Portion of Course 22 Description

C 22; Energy Use Modelling & Analysis

- Ener M A (in Calendar Table)
- Understand energy consumption in building systems
- Energy use in res. building systems and applications
- Prepare opinions on cooling energy loads using hand calculations and available software models
- Understand typical building designs, common building materials, and their impact on associated comfort
- Identify energy efficient upgrades for existing buildings

1. Portion of Course 22 Description

C 22: Energy Use, Modeling and Analysis

Examples of anticipated outcomes after course completion

- Review and make calculated estimates of average and peak loads for types of residential building energy uses
- For a customer's house, consider currently used materials, designs, and habits, and reasonably potential changes
- Make reasonable technical suggestions for improving energy efficiency, and their financial effectiveness

1. Portion of Course 22 Description

From Learning Outcomes and Tasks

Task 01

<u>Understand energy consumption in building systems</u>

- Unit conversions
- Conductance, Resistance, Wall Dimensions, Thickness
- Heat, Cool, Lights, Equipment, Industrial use
- Electricity, On-site fossil fuel use, Low carbon sources

1. Portion of Course 22 Description

From Learning Outcomes and Tasks

Task 02

<u>Energy use in residential building systems & applications</u>

- BZ Bldg – Concrete, Block, Wood framed upper floors
- WUFI Software – Heat and Moisture Transiency
- Passive House Planning Package (Software)
- RetScreen (Software)

1. Portion of Course 22 Description

From Learning Outcomes and Tasks

Task 03

Prepare opinions on cooling energy loads using hand calculations and available software models

- Info. Sources, Working Assumptions, Measurements, Calculations, Conversions. And Uncertainties
- Residential (Belize) Building Scenario
- Commercial (Belize) Building Scenario

1. Portion of Course 22 Description

From Learning Outcomes and Tasks

Task 04

Understand typical building designs, common building materials, and their impact on associated comfort

- Belize and North American examples
- Moisture flows, humidity, vapour barriers, temperature
- BuildingScience.com information resources

1. Portion of Course 22 Description

From Learning Outcomes and Tasks

Task 05

<u>Identify energy efficient upgrades for existing buildings</u>

- Heating and Cooling
- Lighting
- Cooking
- Plug In equipment

1. Portion of Course 22 Description

Marking Breakdown

- 20% Individual Tests
- 30% Individual Projects
- 40% Group Projects
- 10% Employability Skills

1. Portion of Course 22 Description

Marking Breakdown

20% Individual Tests (Examples)

- Task 1 Understand Energy Consumption
- Task 5 Identify energy efficient upgrades

1. Portion of Course 22 Description

Marking Breakdown

30% Individual Projects (Examples)

- Task 3 Prepare opinions on cooling energy loads
- Task 2 Energy Use in Buildings
  - WUFI Software – Heat and Moisture Transiency
  - Passive House Planning Package (Software)

1. Portion of Course 22 Description

Marking Breakdown

40% Group Projects (Examples)

- Task 4 Understand typical building designs
  - BuildingScience.com information resources
- Task 2 Energy Use in Buildings
  - RET Screen (Software)

1. Portion of Course 22 Description

Marking Breakdown

10% Employability Skills (Examples)

- Those used in ITVET Belize communications courses
- Attendance
- Timeliness
- Attention to detail

C22 Goal with Software Tools

Course 22: Energy Modeling

Goal is student or course participant familiarity with tools and potential BZ applications, not to master each application.

1. Portion of C22 Course Description
2. BuildingScience.com
3. WUFI Software - Heat and Moisture Transiency
4. PHPP – Passive House Planning Package (PHPP)
5. RET Screen

2. BuildingScience.com

Building Science.com

Task 04

Understand typical building designs, common building materials, and their impact on associated comfort

- Belize and North American examples
- Moisture flows, humidity, vapour barriers, temperature
- BuildingScience.com information resources



2. BuildingScience.com

Building Science.com

Task 04

Building Science Corporation (private sector services)

- Articles, Papers, Guidance documents available online
- Events & Training (e.g. online $$/session; CEU credits)
- Document Search (e.g. Type; Climate Zone)
  - BA 1208 Performance of a Hot-Humid Climate Community (Available for Download – Copied for this session)



2. BuildingScience.com

Building Science.com

Task 04

Designs That Work (from Document Search and Filter)

- DTW: New Orleans - Project Home Again Phase 1 & 2
- Case Studies of affordable and energy efficient detached homes (After Katrina: Copy for this session)
- https://www.buildingscience.com/documents/case-studies/cs-la-new-orleans-pha/view



2. BuildingScience.com

Case Study

Project Home Again

New Orleans, Louisiana

Overview

Project Home Again is a not-for-profit organization that is overseeing the construction of 20 affordable and energy efficient single detached residences in Gentilly, New Orleans. The project is managed by Green Coast Enterprises, a local real estate services firm. A local architect and builder (Sustainable Architecture, LLC. and TKTMJ, Inc., respectively) were hired in large part because of their extensive expertise and willingness to embrace Building America building practices. These single detached homes demonstrate the energy efficiency and durability upgrades that Building Science Corporation (BSC) advocates. These community homes are located on St. Bernard Avenue in Gentilly, New Orleans.

BSC recommended building upgrades that address energy efficiency, occupant comfort, affordability, sustainability, and durability. Key upgrades include an enclosure that is fully insulated and air-sealed with high density spray foam and supplemental dehumidification. Other upgrades that contributed to increased building efficiency and durability are state of the art LoE spectrally selective vinyl windows and a high efficiency HVAC system.

The development is currently on-time and meeting budget. This is a great

HOT HUMID CLIMATE

U.S. Department of Energy

Energy Efficiency and Renewable Energy

Project Profile

Project Team: Project Home Again, TKTMJ, Inc., Green Coast Enterprises, Sustainable Architecture, LLC., National Renewable Energy Laboratory (NREL), Building Science Corporation

Address: St. Bernard Avenue, New Orleans, LA

Description: A mix of 1,016 ft² one- and 1,544 ft² two-story single family detached homes

Completion Date: April, 2009

Estimated Annual Energy Savings: Average 42% projected source energy savings relative to the 2008 Building America benchmark

Project Website: www.projecthomeagain.net

bsc

Building Science Corporation
30 Forest Street
Somerville, MA 02143
www.buildingscience.com

Project Home Again – New Orleans

- Enclosure Design
- Mechanical Design
- Lessons Learned & Future Projects
- Technology Gaps and Barriers
- https://www.buildingscience.com/documents/case-studies/cs-la-new-orleans-pha/view

3. WUFI Software: Heat & Moisture

Task 02

Energy use in residential building systems & applications

- BZ Bldg – Concrete, Block, Wood framed upper floors
- **WUFI Software – Heat and Moisture Transiency**
- Passive House Planning Package (Software)
- RetScreen (Software)

3. WUFI Software: Heat & Moisture

- Germany https://wufi.de/en/
- dynamic simulations of heat and moisture transfer
- vapour diffusion and liquid transfer
- outdoor boundary conditions – rain and solar radiation
- Whole building climate and energy simulations
- user defined climate conditions
- Passive house calculations

3. WUFI Software: Heat & Moisture

- Germany https://wufi.de/en/
- WUFI® Plus Free and WUFI® Passive Free are free versions of WUFI® Plus and WUFI® Passive. (thermal only – free limited use for 1 year per email account)
- Educational Institution and Student rates as well as some limited uses
- Manuals in PDF copied for this session

4. Passive House Planning Package

International PASSIVE HOUSE Association iPHA

Task 02

Energy use in residential building systems & applications

- BZ Bldg – Concrete, Block, Wood framed upper floors
- WUFI Software – Heat and Moisture Transiency
- **Passive House Planning Package (Software)**
- RetScreen (Software)
- Prepare project proposals, estimates, quotes, invoices

4. Passive House Planning Package

International Passive House Association (IPHA) (Germany):

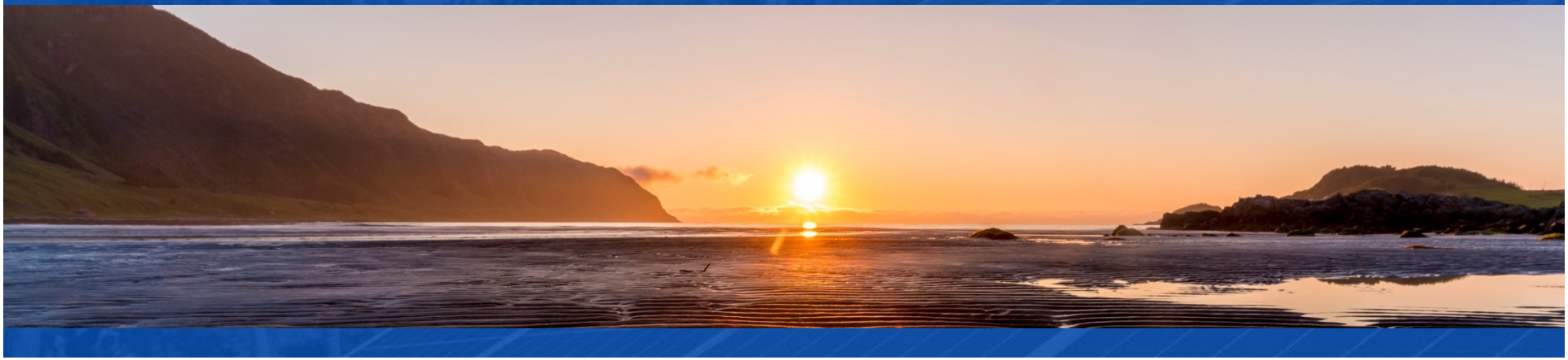
https://passivehouse-international.org/index.php?page_id=188

- Passive House Planning Package (PHPP) software
- Design PH – 3D modeling tool for PHPP ~$US 250
- Courses available ($$ for consultants after ITVET?)
- Available resources (free) online useful for Course C22

4. Passive House Planning Package

Step by Step retrofits (EuroPHit) :

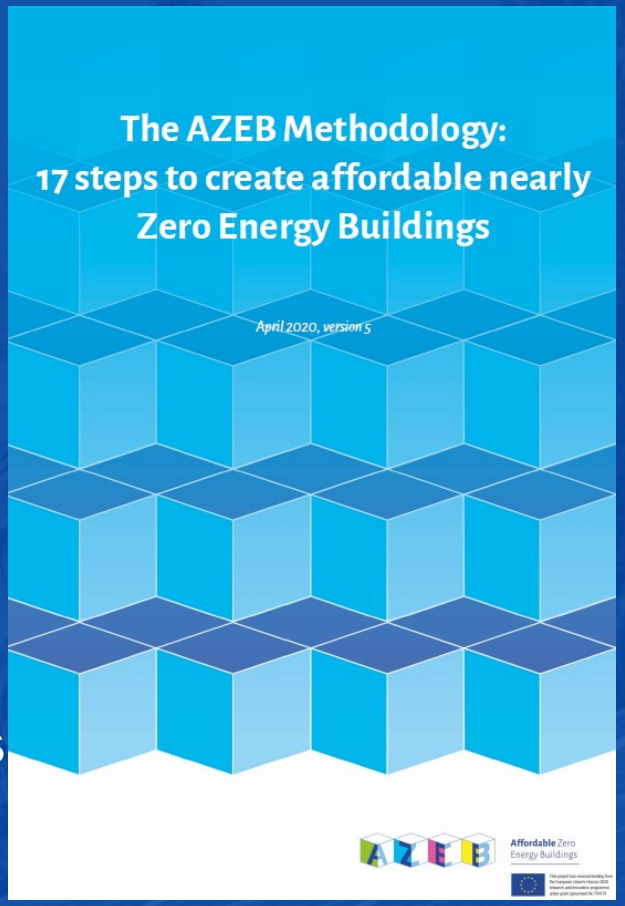
- 124 p PDF file copied for this Session
- A Course C22 Classroom Resource
- Building Envelope (e.g. connections)
- Building Services (e.g. using solar)



4. Passive House Planning Package

<u>AZEB Methodology: 17 Steps to Create affordable nearly Zero Energy Buildings</u>:

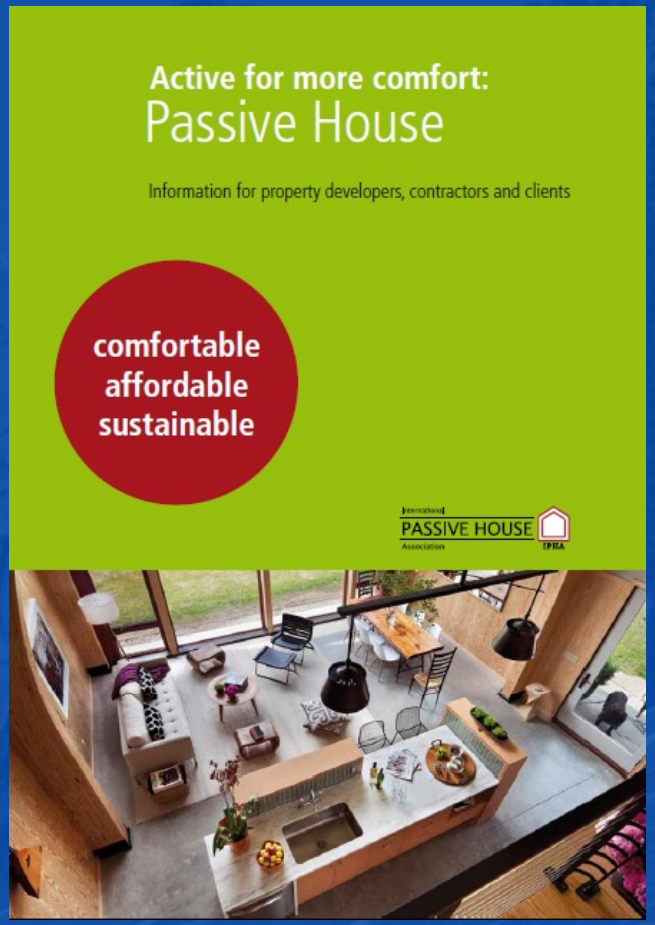
- 78 p PDF file copied for this Session
- For each of the 17 steps:
  - Stakeholders and main activities
  - Suggested tools methods and references
  - Example of potential impact
  - Categorization



4. Passive House Planning Package

IPHA Active for more comfort brochure:

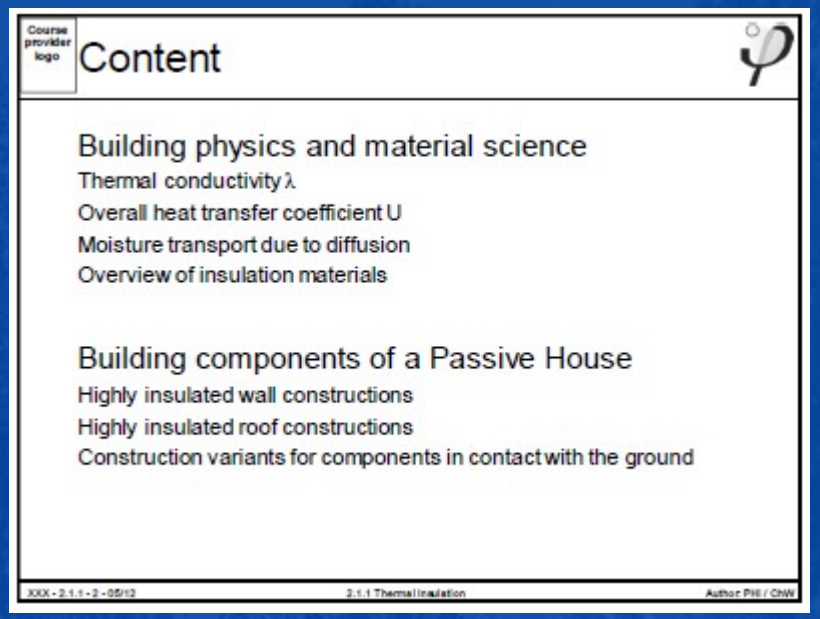
- 68 p PDF file copied for this Session
- Resource - text, pictures, & drawings
- “Passive House” features include:
  - Exceptionally high levels of insulation
  - Air tight Building Envelope
  - Ventilation with heat & energy recovery
- For some ICI Belize applications?



4. Passive House Planning Package

IPHA Sample Course Slides:

- 2.1.1 Thermal Insulation
- 11 p PDF (22 slides)
- A C22 Classroom Resource
- (House) Building components
- (House) Building physics and material science


Course provider logo

Content

Building physics and material science

Thermal conductivity λ

Overall heat transfer coefficient U

Moisture transport due to diffusion

Overview of insulation materials

Building components of a Passive House

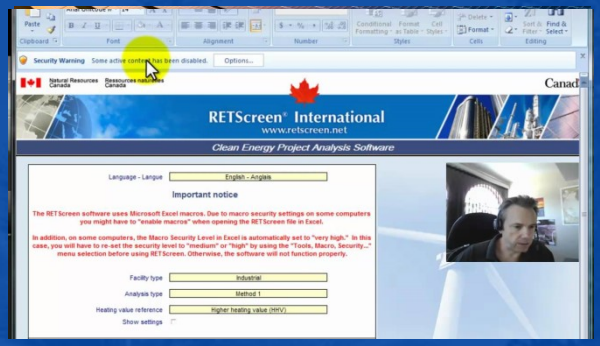
Highly insulated wall constructions

Highly insulated roof constructions

Construction variants for components in contact with the ground

XXX - 2.1.1 - 2 - 05/12 2.1.1 Thermal insulation Author PHI / CNW

5. RETScreen Software Tool

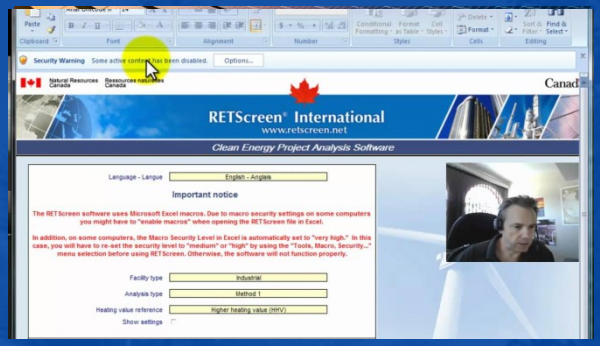


Providing Instructor with "Trade" related Course Material Examples

- Locally inspired examples for assignments and tests
- Software Examples
  - WUFI Software – Heat and Moisture Transiency
  - Passive House Planning Package (Software)
  - RETScreen (Software)
-



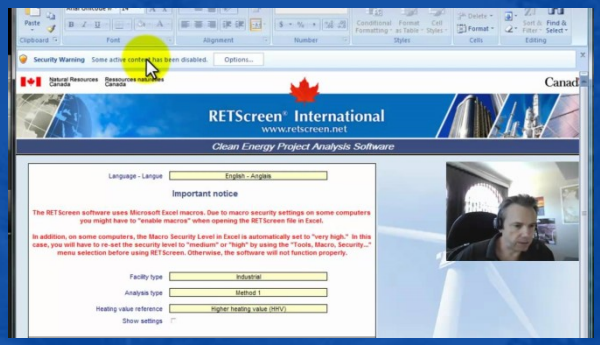
5. RETScreen Software Tool



Renewable Energy and Energy Efficiency Technology Screen

- Excel Software from by Natural Resources Canada
- Download for Free – RETScreen Version 4
- Pay for more current version
- Quick and inexpensive way to determine technical and financial viability of potential renewable energy, energy efficiency, and cogeneration projects.

5. RETScreen Software Tool

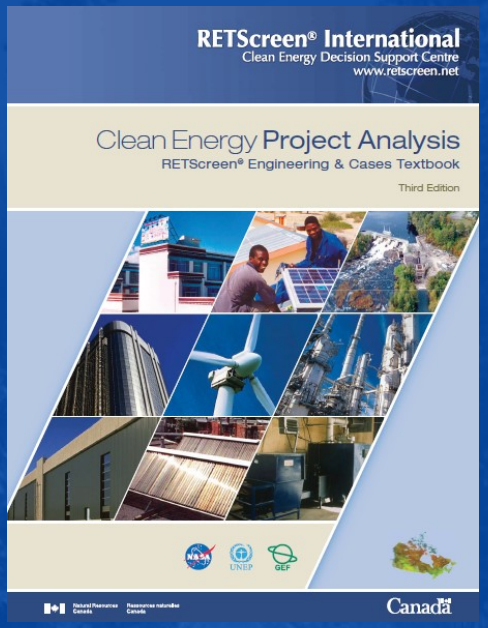


Available Online Tutorials

- Version 4 RETScreen
- https://www.youtube.com/watch?v=xi6vyA80Nds
- https://www.youtube.com/watch?v=2T07FdAIT4c
- https://www.youtube.com/watch?v=xICZOzNIW4s&list=PL37A8D6844FB50866&index=4&t=49s
- https://www.youtube.com/watch?v=F3HsYt7gDAs&list=PL37A8D6844FB50866&index=4



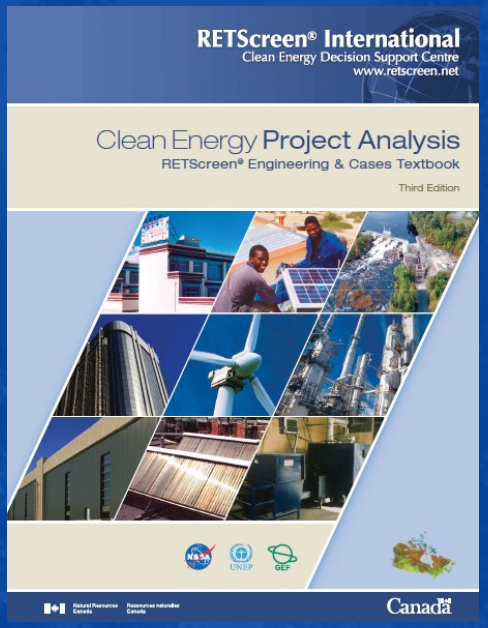
5. RETScreen Software Tool



Engineering and Course Textbook (2005)

- 456 p PDF copied for this session
- Intro to Clean Energy Project Analysis
- Wind Energy Project Analysis
- Small Hydro Project Analysis
- Photovoltaic Project Analysis
- Combined Heat and Power Project Analysis

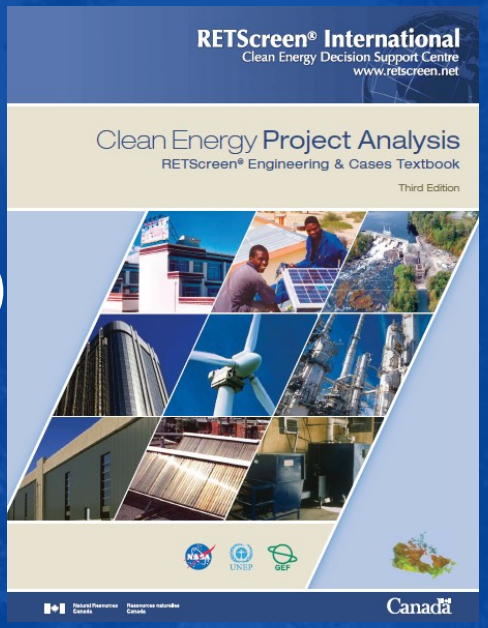
5. RETScreen Software Tool



Engineering and Course Textbook (2005)

- Biomass Heating Project Analysis
- Solar Air Heating Project Analysis
- Solar Water Heating Project Analysis
- Passive Solar Heating Project Analysis
- Ground Source Heat Pump Project Analysis

5. RETScreen Software Tool



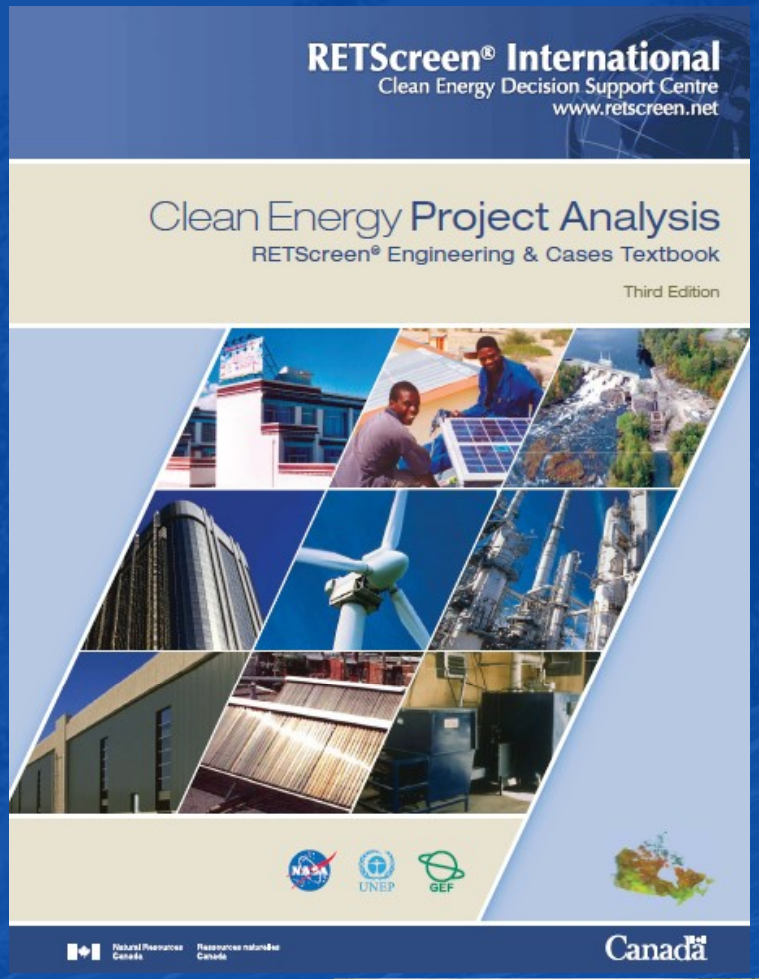
Project Analysis (General Layout)

- Background (e.g. Project Development)
- Project Model
  - Site Conditions / Applied Science
  - Load, variables, utilization
  - Energy Production, Delivery and Fuel Consumption
  - Project Costing and Savings
  - Validation
  - Summary

5. RETScreen Software Tool

Technical Communication Tools

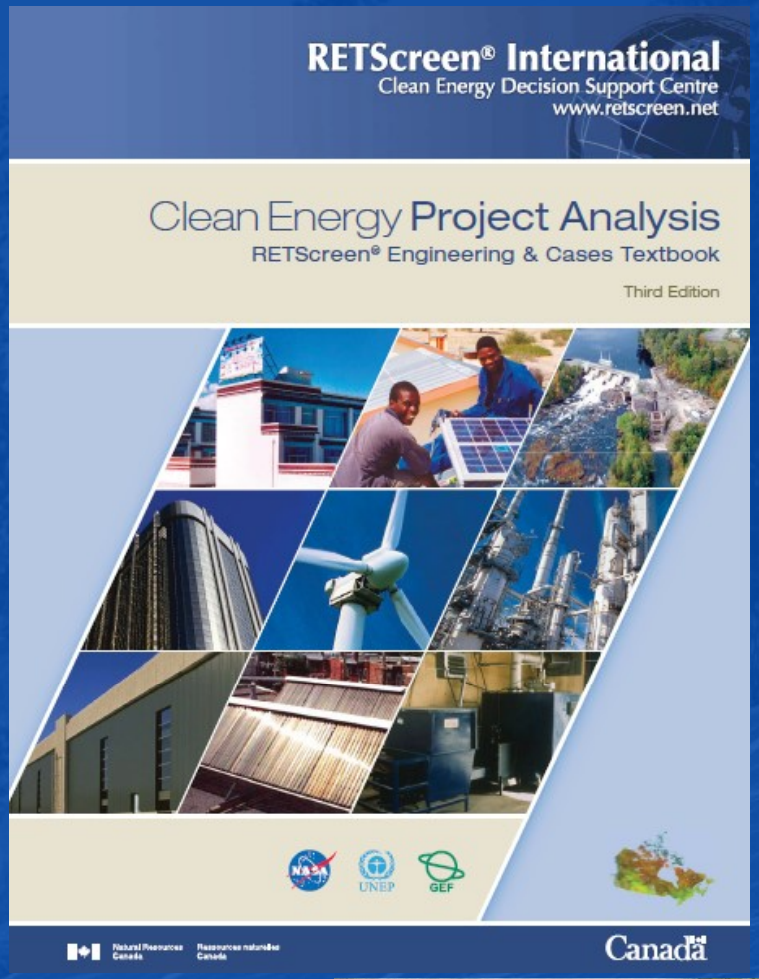
- Text
- Equations
- Tables
- Graphs
- Photos
- Drawings



5. RETScreen Software Tool

Content cross over opportunities

- C 21 Communications 2
- C 31 Communications 3
- C 32 Applied Math 2
- C 33 Solar Hot Water
- C 34 PV Installations
- C 35 Technical Drawing



5. RETScreen Software Tool

RETScreen Application in other courses

- C 22 Energy Modeling & Analysis
- RETScreen activities in course
  - Computer use of RETScreen Version 4
  - Adapt a RET Screen Project Analysis to a Belize Scenario
  - Applications for C31 Comms 3, C32 Math 2, C35 Tech Drwg
  - Spreadsheet Calculation – C35 PV Installation application
  - Spreadsheet Calculation - C34 Solar Hot Water application



5. RETScreen Software Tool

RETScreen Application in other courses

- C 14 PV Applications
- Lab 2 (Energy Estimation)
  - Climate Data from Phillip Gold Airport
  - Calculate Solar Energy Resource Estimate
  - Calculate Annual Energy Production
    - By 1-Axis, 2-Axis, and azimuth tracking
  - Describe how to get the most energy, and prove it by calculations



5. RETScreen Software Tool

RETScreen Application in other courses

- C 33 PV Solar Hot Water
- Notes on Solar Hot Water Application
  - Text by Gord Wilkie (13 p PDF)
  - Graphics from windows within RETScreen program
  - Resource Assessment, Product Database, and Misc. losses
  - Calculate for Glazed Flat Plat Collector system
  - Calculate for Apricus evacuated tube thermo siphon system



6. ITVET Education Licenses

ITVET Education Software Licenses

- Institution / Instructor / Student?
- ITVET owned Hardware / Software or not applicable?
- Price reduction / Price elimination / No change?
- Limited use / Limited time?
- Using older “free” public domain software may be easier for access by ITVET course participants



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Summary

Course 22: Energy Modeling

- 46.7 Classroom hours
- 10 Week Term 2, Year 1
- Build on C 13 Energy Science
- Add “Trade” related examples

1. Energy Efficiency Courses in 2 year RE EE Program
2. Session 01 – Course C22 Context, Description, Development, and what “success” looks like
3. Session 02 – Introduction to some software tools and available online information resources
4. Development of Course 22
   - Opportunities for focused Winter 2023 Sessions

For Today:

C 22: Energy Modelling & Analysis

- Instructor Comments?
- Instructor Discussion?
- Instructor Suggestions?
- "Real World" Applications?

- Session 2 of 2 (December 16, 2022)
  - WUFI Software – Heat and Moisture Transiency
  - Passive House Planning Package (Software)
  - RetScreen (Software)
  - Examples of Assignment, Test, and Project text

Questions?

Comments?

Suggestions?

Thank you