

**FARG‘ONA DAVLAT TEXNIKA UNIVERSITETI HUZURIDAGI ILMIY
DARAJALAR BERUVCHI PhD.03/07.06.2024.T.106.06 RAQAMLI
ILMIY KENGASH**

FARG‘ONA DAVLAT TEXNIKA UNIVERSITETI

XALIMOV ABBOSBEK OYBEK O‘G‘LI

**EKSPLUATATSIYADAGI KO‘P KVARTIRALI UYLARNING ENERGIYA
SAMARADORLIGINI BAHOLASH VA OSHIRISH MASALALARI**

05.09.01 – Qurilish konstruksiyalari, bino va inshootlar

**Texnika fanlari bo‘yicha falsafa doktori (PhD) dissertatsiyasi
AVTOREFERATI**

Farg‘ona-2025

**Texnika fanlari bo‘yicha falsafa doktori (PhD) dissertatsiya
avtoreferati mundarijasi**

**Contents of dissertation abstract of doctor of philosophy (PhD) on technical
sciences**

**Оглавление автореферата диссертации доктора философии (PhD) по
техническим наукам**

Xalimov Abbosbek Oybek o‘g‘li

Ekspluatatsiyadagi ko‘p kvartirali uylarning energiya samaradorligini baholash va oshirish masalalari.....3

Khalimov Abbosbek Oybek ugli

Issues of assessing and improving energy efficiency of operating apartment buildings.....21

Халимов Аббосбек Ойбек угли

Вопросы оценки и повышения энергоэффективности эксплуатируемых многоквартирных домов..... 39

E‘lon qilingan ishlar ro‘yxati

List of published works

Список опубликованных работ46

**FARG‘ONA DAVLAT TEXNIKA UNIVERSITETI HUZURIDAGI ILMIY
DARAJALAR BERUVCHI PhD.03/07.06.2024.T.106.06 RAQAMLI
ILMIY KENGASH**

FARG‘ONA DAVLAT TEXNIKA UNIVERSITETI

XALIMOV ABBOSBEK OYBEK O‘G‘LI

**EKSPLUATATSIYADAGI KO‘P KVARTIRALI UYLARNING ENERGIYA
SAMARADORLIGINI BAHOLASH VA OSHIRISH MASALALARI**

05.09.01 – Qurilish konstruksiyalari, bino va inshootlar

**Texnika fanlari bo‘yicha falsafa doktori (PhD) dissertatsiyasi
AVTOREFERATI**

Farg‘ona-2025

Falsafa doktori (PhD) dissertatsiyasi mavzusi O‘zbekiston Respublikasi oliy ta’lim, fan va innovatsiyalar vazirligi huzuridagi Oliy attestatsiya komissiyasida B2025.3.PhD/T5810 raqam bilan ro‘yxatga olingan.

Doktorlik dissertatsiyasi Farg‘ona davlat texnika universitetida bajarilgan.

Dissertatsiya avtoreferati uch tilda (o‘zbek, rus, ingliz (rezyume)), Ilmiy kengashning veb-sahifasida (www.fstu.uz va “ZiyoNet” Axborot-ta’lim portalida www.ziyounet.uz) joylashtirilgan.

Ilmiy rahbar:

Xotamov Asadulla Toshtemirovich
texnika fanlari doktori, professor

Rasmiy opponentlar:

Yuvmitov Anvar Sayfullayevich
texnika fanlari doktori, katta ilmiy xodim

Norov Nusiratjon Nuralievich
texnika fanlari bo‘yicha falsafa doktori, dotsent

Yetakchi tashkilot:

Namangan davlat texnika universiteti

Dissertatsiya himoyasi Farg‘ona davlat texnika universiteti huzuridagi Ilmiy darajalar beruvchi PhD.03/07.06.2024.T.106.06 raqamli Ilmiy kengashning 2025 yil “31” oktabr soat 14³⁰ dagi majlisida bo‘lib o‘tadi. (Manzil: Farg‘ona viloyati, Farg‘ona shahar, Farg‘ona ko‘chasi, 86 - uy. Tel.: (99873) 241–12–06; e-mail: info@fstu.uz).

Dissertatsiya bilan Farg‘ona davlat texnika universiteti Axborot - resurs markazida tanishish mumkin (№ 296–raqami bilan ro‘yxatga olingan). (Manzil: Farg‘ona shahar, Farg‘ona ko‘chasi, 86 - uy. Tel.: (99895) 028–42–20; faks: (99895) 028 42 20, e-mail: fstuarm@edu.uz).

Dissertatsiya avtoreferati 2025 yil “17” oktabr kuni tarqatildi.
(2025 yil “15” oktabrdagi № 1/2025-7 raqamli reestr bayonnomasi).

S.F. Ergashev
Ilmiy darajalar beruvchi
ilmiy kengash raisi
texnika fanlari doktori, professor

Sh.A. Umarov
Ilmiy darajalar beruvchi
ilmiy kengash ilmiy kotibi,
texnika fanlari bo‘yicha falsafa doktori, dotsent

X.A. Akramov
Ilmiy darajalar beruvchi
ilmiy kengash qoshidagi Ilmiy seminar raisi,
texnika fanlari doktori, professor

KIRISH (falsafa doktori (PhD) dissertatsiya annotatsiyasi)

Dissertatsiya mavzusining dolzarbligi va zarurati. Jahonda energiya resurslariga bo'lgan talabning barqaror o'sayotgani munosabati bilan zamonaviy binolarni loyihalash hamda ekspluatatsiyadagi binolarni kapital ta'mirlash jarayonlarida energiya samaradorligini oshirish va isitish uchun sarflanadigan energiyadan samarali foydalanish masalalariga katta ahamiyat berilmoqda. Hozirgi kunda dunyo bo'yicha 2024-yil energiyaga bo'lgan talab 2,2% ga o'sib, jami 640×10^{18} joul (640 eksadjoul)ni tashkil etmoqda. Elektr energiyasiga bo'lgan talab ayniqsa sezilarli o'sib, 4,3% ga ortib, global yalpi ichki mahsulot o'sishidan (3,2%) yuqori darajaga ko'tarildi. Binolarda elektr energiyasi iste'moli 2024-yilda rekord darajada oshib, global iste'molning 60% ini tashkil qildi, bu esa isitish va sovutish ehtiyojlarining oshishi bilan bog'liq. Bu borada, jumladan binolarning energiya samaradorligini oshirish, energiya iste'molini oqilona boshqarish va tejash bo'yicha amaliy yechimlar ishlab chiqish dolzarb ahamiyat kasb etmoqda.

Jahon amaliyotida binolarning energiya samaradorligini ta'minlashga qaratilgan keng qamrovli ilmiy-tadqiqot ishlari olib borilmoqda. Ushbu tadqiqotlarda binolar tashqi to'siq konstruksiyalari orqali yo'qoladigan energiya miqdorini kamaytirish, hamda konstruksiyalarni takomillashtirish ustuvor ahamiyat kasb etmoqda. Rivojlangan davlatlarda, xususan AQSh, Kanada, Germaniya, Finlandiya, Rossiya, Xitoy va Yaponiya kabi mamlakatlarda, energiya tejamkor binolarni loyihalash va mavjud inshootlarni energiya samaradorligini oshirish bo'yicha katta tajriba to'plangan. Binolarning energiya samaradorligini yanada yaxshilash maqsadida yangi konstruktiv yechimlar ishlab chiqilib, amaliyotga tatbiq etilmoqda, jumladan binolar energiya samaradorligini baholash va tashqi to'siq konstruksiyalari orqali yo'qotiladigan issiqlik miqdorlarini kamaytirish usullarini takomillashtirish dolzarb vazifalardan hisoblanmoqda.

Respublikamizda so'nggi yillarda sohada binolar energiya samaradorligini oshirishga yordam beradigan yangi texnologiyalarni ishlab chiqish va ularni amalda qo'llash bo'yicha keng ko'lamlı islohotlar amalga oshirilmoqda. "Yashil texnologiyalar bo'yicha ilmiy tadqiqotlar olib borish",¹ "Yangi quriladigan bino-inshootlar va uy-joylar energiya samaradorligidan kelib chiqib, "Yashil bino" sertifikatı joriy etilishini ta'minlash"² vazifalari belgilangan. Bu borada, jumladan ko'p kvartirali uylarning energiya samaradorlik darajasini aniqlash va baholash uslublarini yanada takomillashtirish, shuningdek, ilg'or issiqlik saqlovchi qurilish materiallari, innovatsion konstruktiv yechimlarni amaliyotga keng joriy etish orqali binolarning issiqlik himoya ko'rsatkichlarini oshirish masalasi muhim ilmiy-amaliy vazifa sifatida dolzarb ahamiyatga ega.

O'zbekiston Respublikasi Prezidentining 2025-yilni "Atrof muhitni asrash va "yashil" iqtisodiyot yili" deb e'lon qilishi, shuningdek, 2022-yil 28-yanvardagi PF-60-son "2022-2026 yillarga mo'ljallangan yangi O'zbekiston taraqqiyot strategiyasi

¹ O'zbekiston Respublikasi Prezidentining 2025 yil 11 martdagi PQ-100-sonli "Uy-joy hamda bino-inshootlarni issiqlik energiyasi bilan ta'minlash sohasini tubdan isloh qilish hamda binolarning energiya samaradorligini oshirish chora-tadbirlari to'g'risida"gi qarori.

² O'zbekiston Respublikasi Prezidentining 2025 yil 30 yanvardagi PF-16-sonli "O'zbekiston — 2030" strategiyasini "Atrof-muhitni asrash va "yashil iqtisodiyot" yilida amalga oshirishga oid davlat dasturi to'g'risida"gi farmoni.

to'g'risida", 2023-yil 11-sentabrdagi PF-158-son "O'zbekiston – 2030" strategiyasi to'g'risida"gi farmonlari, 2023-yil 16-fevraldagi PQ-57-son "2023-yilda qayta tiklanuvchi energiya manbalarini va energiya tejovchi texnologiyalarni joriy etishni jadallashtirish chora-tadbirlari to'g'risida", 2025-yil 11-martdagi PQ-100-son "Uy-joy hamda bino-inshootlarni issiqlik energiyasi bilan ta'minlash sohasini tubdan isloh qilish hamda binolarning energiya samaradorligini oshirish chora-tadbirlari to'g'risida"gi qarorlarida belgilangan vazifalarni amalga oshirishda va ushbu sohadagi me'yoriy-huquqiy hujjatlarda ko'rsatilgan maqsadlarga erishishda mazkur dissertatsiya tadqiqoti ma'lum darajada hissa qo'shadi.

Tadqiqotning respublika fan va texnologiyalari rivojlanishining ustuvor yo'nalishlariga mosligi. Dissertatsiya ishi O'zbekiston Respublikasi fan va texnologiyalari rivojlanishining II. «Energetika, energiya va resurs tejamkorligi» ustuvor yo'nalishiga mos ravishda bajarilgan.

Muammoning o'rganilganlik darajasi. Energiya samaradorlik masalasi butun dunyo bo'yicha dolzarb bo'lganligi sababli bu soha bo'yicha doimiy izlanishlar olib borilmoqda. Bu mavzu bo'yicha Xorijiy va MDH mamlakat olimlari: R.M.Aloyan, S.V.Fedosov, L.A.Oparina, N.V.Pilipenko, Y.G.Kiseleva, M.S.Myagkovva, A.Lari, V.M.Fokin, A.Galata, J. M.Andujar, S.G.Melgar, A.E.Kiryudcheva, D.O.Sovetnikov, P.V.Monastrev, A.M.Makarov, S.V.Kornienko, C.Costantino, A.C.Benedetti, R.Gulli, V.Milich, P.Rohdin, M.Upis, I.Amolina, I.Geypele, N.Zeltins, A.Papoyan, Ch.Jan, S.Xan, G.Li, Jang H. va boshqa bir qancha olimlar tadqiqotlar olib borishgan.

Mamlakatimizda fuqaro binolarining energiya samaradorligi sohasida M.M.Zoxidov, G'.Sh.Shukurov, S.M.Maxmudov, E.S.Tulakov, binolarning energiya samaradorligini oshirish bo'yicha, R.Y.Marakaev, N.N.Norov, O'zbekiston sharoitida energiya samarali binolarni loyihalash bo'yicha, J.V.Eshmurodov, Q.Edmurodov, S.A.Xodjaev, R.R.Qadirov, E.V.Shipacheva, M.Nabiyev quruq issiq iqlim sharoitida energiyasamarador binolarni loyihalash bo'yicha, M.A.Koroli, M.B.Xudiyarov bino energetik auditi yo'nalishlari bo'yicha samarali ilmiy izlanishlar olib borishgan. Turar joy maskanlarida binolarning energiya samaradorligiga to'g'ridan-to'g'ri ta'sir ko'rsatuvchi, ularni ufqqa nisbatan optimal joylashtirish, bunda binolarning o'zaro joylashuviga ta'sir etuvchi tabiiy, texnogen va antropogen omillar I.S.Shukurov, A.T.Xotamov, X.F.Allaberganov, B.E.Dusatovlar tomonidan o'rganilmoqda.

Tahliliy ko'rsatkichlardan kelib chiqib, ko'p kvartirali uylarning energiya samaradorligini baholash muammosi hali to'liq o'rganilmagan. Ko'p kvartirali uylarning energiya samaradorligini aniqlash usullari respublikamizning hududiy va iqlim sharoitlarini inobatga olgan holda amalga oshirish metodlarini tadqiq etish zaruriyatini keltirib chiqaradi.

Dissertatsiya tadqiqotining dissertatsiya bajarilgan oliy ta'lim muassasasining ilmiy-tadqiqot ishlari rejalari bilan bog'liqligi. Dissertatsiya tadqiqoti Farg'ona davlat texnika universitetining ilmiy tadqiqot ishlari rejasiga muvofiq "Barqarorlik va sanoat innovatsiyalari dasturi" (2024-2025) mavzusidagi loyiha doirasida bajarilgan.

Tadqiqotning maqsadi mavjud ko'p kvartirali uylarning energiya samaradorligini baholash, tashqi to'siq konstruksiyalardan yo'qotilayotgan issiqlik miqdorini kamaytirish usullarini aniqlashdan iborat.

Tadqiqotning vazifalari:

binolarda energiya samaradorligini baholash va oshirishga doir ilmiy adabiyotlar va amaliy tadqiqotlarni baholash;

Farg'ona shahar, Qirguli mavzesida joylashgan mavjud ko'p kvartirali uylarni monitoring qilish hamda energiya yo'qotishlari bilan bog'liq asosiy muammolarni aniqlash;

ko'p kvartirali uylarda energiya samaradorligini baholashning nazariy-metodik asoslarini aniqlash;

ko'p kvartirali uylarni energiya samaradorligini baholash usullarini takomillashtirish bo'yicha hisob-kitoblarni avtomatlashtiruvchi elektron platforma ishlab chiqish;

ko'p kvartirali uylarning tashqi to'siq konstruksiyalaridan issiqlik yo'qotilishini kamaytiruvchi konstruktiv va texnik yechimlarini ishlab chiqish;

taklif etilgan yechimlarning iqtisodiy samaradorligini baholash orqali ularning amaliy qiymatini aniqlash.

Tadqiqotning obyekti sifatida Farg'ona shahar Qirguli mavzesidagi ekspluatatsiyadagi ko'p kvartirali uylar olingan.

Tadqiqotning predmetini ekspluatatsiyadagi ko'p kvartirali uylarning energiya samaradorligi, xususan ularning issiqlik himoyasi darajasini baholash va oshirishga qaratilgan uslubiy va amaliy jihatlar tashkil etadi.

Tadqiqotning usullari. Tadqiqotda statistik tahlil, baholash, real obyektlarda o'tkazilgan naturaviy tekshiruvlar va qiyoslash usullaridan foydalanilgan.

Tadqiqotning ilmiy yangiligi quyidagilardan iborat:

ko'p kvartirali uylarning energiya samaradorligini baholash uslubi bino kapital ta'mirlangandagi konstruksiyalarni issiqlik o'tkazishga bo'lgan qarshiliklaridagi o'zgarishlarni inobatga oluvchi algoritmi ishlab chiqish hisobiga takomillashtirilgan;

ko'p kvartirali uylarning energiya samaradorligini qisqa vaqtda kompleks baholash hamda uni issiqlik energetik sinfini binoning solishtirma issiqlik sarfi miqdori o'zgarishiga asosan oshirish imkonini beruvchi onlayn hisoblash platformasi ishlab chiqilgan;

ko'p kvartirali uylarning texnik holatini instrumental-texnik tekshirish va energiya samaradorligini baholash ishlarini integratsiyalashgan yondashuvga ko'ra birgalikda amalga oshirish orqali mehnat hamda vaqt resurslarini 20% ga kamayishi aniqlangan;

ko'p kvartirali uylarning tashqi devorlari izolyatsiyasida fasad panellari konstruksiyalarining soddalashtirilganligi va o'rnatish jarayonining mexanizatsiyalashgani sababli ventilyatsiyali fasadga nisbatan montajda vaqt hamda ishchi kuchi xarajatlarining kamayishi hisobiga 1,1 barobar iqtisodiy samaradorlikka erishilishi isbotlangan.

Tadqiqotning amaliy natijalari quyidagilardan iborat:

ko'p kvartirali uylarning energiya samaradorligini baholash jarayonida kapital ta'mirdan keyingi konstruktiv, texnologik o'zgarishlar inobatga olinib, baholashning aniqligi va ishonchliligi ta'minlangan hamda uslubiy mexanizm takomillashtirilgan;

binolarning energiya samaradorligini qisqa muddatda hisoblash va issiqlik energetik sinfini aniqlash imkonini beruvchi energiyasamaradorbino.uz

avtomatlashtirilgan onlayn hisoblash platformasi ishlab chiqilgan;

ko'p kvartirali uylarning texnik holatini instrumental-texnik tekshirish va energiya samaradorligini baholash jarayonlari birgalikda amalga oshirilib, mehnat hamda vaqt resurslaridan oqilona foydalanish imkoniyati yaratilgan;

tashqi devor izolyatsiyasida ventilyatsiyali fasad panellaridan foydalanishning texnologik jarayonlari chuqur o'rganilib, montajning quruq usulda bajarilishi qurilish samaradorligini oshirgan hamda ularning texnologik afzalliklari asoslangan.

Tadqiqot natijalarini ishonchliligi. Tadqiqot jarayonida foydalanilgan nazariy hisoblar amaldagi qurilish me'yorlari va qoidalariga asoslangan. Issiqlik yo'qotishiga ta'sir etuvchi omillar kompleks tahlil qilinib, ularning ilmiy asoslangan tartibda tizimlashtirilishi natijalarning ishonchliligini ta'minladi. Shuningdek, ishlab chiqilgan hisoblash algoritmlari asosida ishlovchi onlayn platforma orqali olingan natijalar mavjud amaliy holatlarga muvofiqligi bilan izohlanadi.

Tadqiqot natijalarining ilmiy va amaliy ahamiyati. Tadqiqot natijalarining ilmiy ahamiyati ekspluatatsiyadagi ko'p kvartirali uylarning issiqlik himoyasi samaradorligini baholash bo'yicha hududiy sharoitlarga moslashtirilgan onlayn hisoblash algoritmi va platformasining ishlab chiqilishi, shuningdek, konstruktiv yechimlarning issiqlik himoya darajasi bo'yicha ilmiy asoslangan tahlili orqali energiya samaradorlikni baholash nazariyasiga qo'shilgan hissasi bilan izohlanadi.

Tadqiqot natijalarining amaliy ahamiyati mavjud uy-joy fondi uchun energiya tejamkorligini oshirishga xizmat qiluvchi texnik va iqtisodiy jihatdan maqbul konstruksiyalarning tavsiya etilishi, energiyasamaradorbino.uz onlayn platformasi orqali binolarning issiqlik yo'qotishlarini baholash imkoniyati yaratilishi, shuningdek, hisob-kitob natijalari asosida ta'mirlash choralari samarasining oldindan baholash imkoniyati bilan izohlanadi.

Tadqiqot natijalarining joriy qilinishi. Ekspluatatsiyadagi ko'p kvartirali uylarning energiya samaradorligini baholash va oshirish masalalari mavzusida olib borilgan ilmiy tadqiqot natijalari asosida:

ko'p kvartirali uylarning energiya samaradorligini baholash uslubi bino kapital ta'mirlangandagi konstruksiyalarni issiqlik o'tkazishga bo'lgan qarshiliklaridagi o'zgarishlarni inobatga oluvchi algoritmni ishlab chiqish hisobiga takomillashtirilganligi hamda ko'p kvartirali uylarning energiya samaradorligini qisqa vaqtda kompleks baholash hamda uni issiqlik energetik sinfini binoning solishtirma issiqlik sarfi miqdori o'zgarishiga asosan oshirish imkonini beruvchi onlayn hisoblash platformasi ishlab chiqilganligi yuzasidan takliflar "Farg'onafuqaroloyiha" MCHJ loyihalash tashkiloti tomonidan So'x tumani Xirmontepa ko'chasida qurilgan 7 qavatli turar-joy binosi loyahasini ishlab chiqishda foydalanilgan (O'zbekiston Respublikasi Qurilish va uy joy kommunal xo'jaligi vazirligining 2025-yil 10-sentabrdagi 34-06/10251-son ma'lumotnomasi). Natijada issiqlik-texnik hisoblash ishlari an'anaviy usullarga nisbatan vaqtning 25% gacha tejalishiga erishilgan;

ko'p kvartirali uylarning texnik holatini instrumental-texnik tekshirish va energiya samaradorligini baholash ishlarini integratsiyalashgan yondashuvga ko'ra birgalikda amalga oshirish orqali mehnat hamda vaqt resurslarini 20% ga kamayishi aniqlanganligi hamda ko'p kvartirali uylarning tashqi devorlari izolyatsiyasida fasad panellari konstruksiyalarining soddalashtirilganligi va o'rnatish jarayonining

mexanizatsiyalashgani sababli ventilyatsiyali fasadga nisbatan montajda vaqt hamda ishchi kuchi xarajatlarining kamayishi hisobiga 1,1 barobar iqtisodiy samaradorlikka erishilishi isbotlanganligiga oid takliflar “Constraction Test Laboratory” MCHJ tomonidan Marg‘ilon shahar B.Marg‘iloniy ko‘chasida qurilgan 5 qavatli turar-joy binosini qurishda foydalanilgan (O‘zbekiston Respublikasi Qurilish va uy joy kommunal xo‘jaligi vazirligining 2025-yil 10-sentabrdagi 34–06/10251-son ma‘lumotnomasi). Natijada taklif etilayotgan usullar qo‘llanilganda 10% iqtisodiy samaradorlikka erishilgan.

Tadqiqot natijalarining aprobatsiyasi. Dissertatsiya ishining natijalari 8 ta xalqaro va 2 ta respublika ilmiy–amaliy anjumanlarida muhokama qilingan.

Tadqiqot natijalarining e‘lon qilinganligi. Dissertatsiya mavzusi bo‘yicha jami 19 ta ilmiy ish chop etilgan bo‘lib, shulardan, O‘zbekiston Respublikasi Oliy attestatsiya komissiyasining falsafa doktori (PhD) dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan ilmiy nashrlarda 6 ta maqolalar, jumladan, 5 tasi respublika va 1 tasi xorijiy jurnallarda nashr qilingan.

Dissertatsiyaning tuzilishi va hajmi. Dissertatsiya tarkibi kirish, to‘rtta bob, xulosalar, foydalanilgan adabiyotlar ro‘yxati va ilovalardan iborat. Dissertatsiyaning hajmi 120 sahifani tashkil etadi.

DISSERTATSIYANING ASOSIY MAZMUNI

Dissertatsiyaning kirish qismida bajarilgan dissertatsiya tadqiqotining dolzarbligi va zarurati asoslangan, tadqiqotning Respublika fan va texnologiyalarni rivojlantirishning ustuvor yo‘nalishlarga mosligi, tadqiqotning maqsadi va vazifalari hamda tadqiqot obyekti va predmeti keltirilgan, tadqiqotning ilmiy yangiligi va olingan natijalarning ilmiy-amaliy ahamiyati ifodalangan, tadqiqot ishlari natijalarining ishlab chiqarishga tadbiq etilganligi ta‘kidlangan, tadqiqot ishlari natijalarining aprobatsiyasi haqida ma‘lumotlar va dissertatsiya mavzusi bo‘yicha chop etilgan ilmiy maqolalar, shuningdek, dissertatsiya strukturasi va hajmi to‘g‘risidagi ma‘lumotlar keltirilgan.

Dissertatsiyaning **“Turar-joy binolarida energiya tejamkorlik va ularning Farg‘ona shahridagi rivojlanish tendensiyalari”** deb nomlangan birinchi bobida ilmiy-texnik adabiyotlar, mahalliy va xorijiy nashrlar tahlil qilinib, Farg‘ona shahridagi ko‘p kvartirali uylar (KKU) ning mavjud texnik holati, energiya samaradorligi, qurilish tarixi va ularning ekspluatatsiyasi bilan bog‘liq muammolar atroflicha tahlil qilindi. Tadqiqotda global energiya tejamkorlik tendensiyalari, O‘zbekiston va xususan Farg‘ona viloyatidagi uy-joy fondining rivojlanish dinamikasi, shuningdek, Qirguli mavzesidagi KKUlarining texnik va energiya samaradorligi xususiyatlari o‘rganildi.

O‘zbekistonda, xususan Farg‘ona viloyatida uy-joy qurilishining tarixiy va zamonaviy rivojlanishi tahlil qilindi. 2023 yilga kelib, respublikada 47 776 ta KKU mavjud bo‘lib, ularning 9% ga yaqini Farg‘ona viloyatida joylashgan. Farg‘ona shahrida 1960–1990 yillarda qurilgan KKUlar ustunlik qiladi, bu davrda temirbeton va g‘isht konstruksiyalari keng qo‘llanilgan. Farg‘ona viloyatida 4149 ta KKU mavjud bo‘lib, ularning 1554 tasi Farg‘ona shahrida, xususan, Qirguli mavzesida 477 tasi joylashgan. Ushbu binolarning 61% temirbeton, 35,2% g‘isht va 3,1% yog‘och materiallardan qurilgan. 4 qavatli binolar (285 ta) eng ko‘p tarqalgan bo‘lib, asosan 1-464a seriyali panelli uylar va 2 qavatli g‘ishtli uylar tashkil etadi.

Farg‘ona shahridagi KKUlarining ekspluatatsiya muammolari va energiya

samaradorligi masalalari ko‘rib chiqildi. Ko‘pchilik binolarning muhandislik tizimlari eskirgan, issiqlik izolyatsiyasi standartlarga javob bermaydi. Aholining 33% gaz plitalari, 26% elektr isitgichlar, 14% konditsionerlar va 13% tabiiy gaz asosidagi suvli isitish tizimlaridan foydalanadi, bu energiya sarfini va yong‘in xavfini oshiradi. Muammolarga ta‘mirga mablag‘ yetishmasligi, yangi texnologiyalarning yetarli joriy etilmasligi va energiya tejash madaniyatining pastligi sabab bo‘lmoqda.

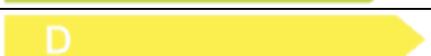
Ushbu bobda Farg‘ona shahridagi KKUlarining texnik holati, energiya samaradorligi va ularning rivojlanish tarixiga oid muhim ma‘lumotlar umumlashtirildi, bu keyingi tadqiqotlar uchun asos bo‘lib xizmat qiladi.

Dissertatsiyaning **“Ko‘p kvartirali uylarga salbiy ta‘sir ko‘rsatuvchi omillar va energiya samaradorlikni baholashning nazariy asoslari”** deb nomlangan ikkinchi bobida, ko‘p kvartirali uylar (KKU) ning energiya samaradorligi tushunchasi, uni baholash metodologiyalari bo‘yicha O‘zbekiston va xorijiy tajribalar, shuningdek, energiya samaradorligiga salbiy ta‘sir ko‘rsatuvchi regional omillar tahlil qilindi. Tadqiqotda binolar energiya samaradorligini oshirishning nazariy va amaliy jihatlari, qurilishdagi zamonaviy yondashuvlar va ularning ekologik barqarorlikka ta‘siri ko‘rib chiqildi.

KKUlarining energiya samaradorligi masalalari atroflicha o‘rganildi. Energiya samarador binolar ikki turga bo‘linadi: energiya tejimli va energiya faol. Tadqiqotda termoizolyatsiya materiallari, isitish va sovitish tizimlari, shamollatish va zamonaviy texnologiyalar integratsiyasining ahamiyati ta‘kidlandi. Bu elementlar energiya sarfini 30–90% ga kamaytirish, ekologik barqarorlikni ta‘minlash va yashash sharoitlarini yaxshilash imkonini beradi. O‘zbekiston Respublikasida binolar energiya samaradorligi 7 ta toifaga bo‘lingan bo‘lib, bular A dan G gacha bo‘lgan darajalarda, A eng yuqori samaradorlikka ega va G eng past darajalar hisoblanadi. (1-jadval)

1-jadval

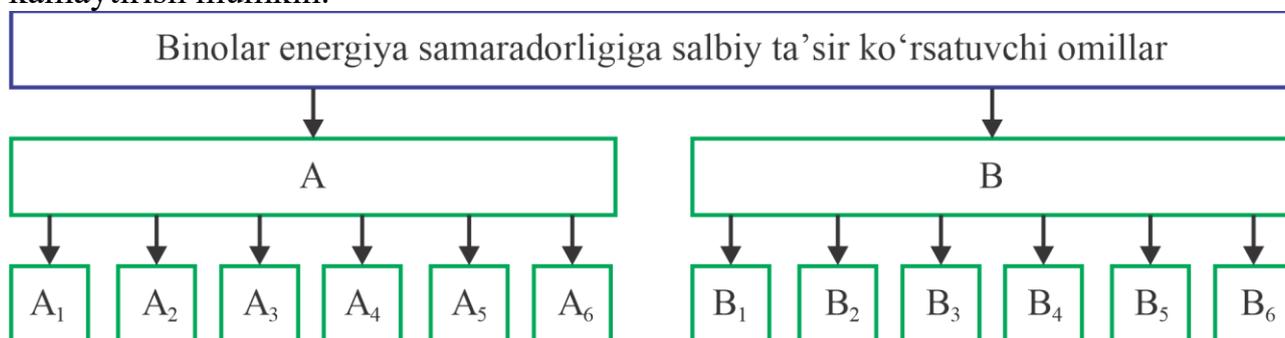
Bino va inshootlarning energiya samaradorligi toifasini belgilash jadvali

Bino va inshootlarning energiya samaradorligi toifasi	Og‘ish kattaligi, %	Tavsiyalar
A 	-40 dan ko‘proq	Iqtisodiy rag‘batlantirish mumkin bo‘lgan energiya samarador bino va inshootlar
B 	-40 dan -26 gacha	
C 	-25 dan -11 gacha	
D 	-10 dan +4 gacha	Normal iste‘mol
E 	+5 dan +14 gacha	Bino va inshootlarda issiqlik yo‘qotishlarini kamaytirish zarur
F 	+15 dan +25 gacha	
G 	+25 dan ko‘proq	Bino va inshootlarni mukammal ta‘mirlash yoki rekonstruksiya qilish talab etiladi

Xorijiy tajribalar, xususan, Energiya Performans of Buildings Direktivasi (EPBD), BREEAM va LEED tizimlari tahlil qilindi. EPBD (2002, 2010, 2018, 2024 yillarda yangilangan) Yevropada energiya sarfini 2030 yilga 60% ga kamaytirish va 2050 yilga nol uglerodli bino fondini yaratishni maqsad qiladi. BREEAM (1990) va

LEED (1993) tizimlari binoning energiya samaradorligi, ekologik barqarorligi va ichki muhit sifatini baholaydi. BREEAM sertifikatlari “Outstanding” dan “Unclassified” gacha, LEED esa “Platina” dan “Sertifikatlangan” gacha darajalarga ega. Bu tizimlar energiya sarfini 30–50% ga kamaytirish, uglerod chiqindilarini qisqartirish va yashash sharoitlarini yaxshilashga xizmat qiladi.

Farg‘ona viloyatidagi KKUlarining eskirishiga ta’sir qiluvchi omillar va ularning energiya samaradorligiga ta’siri ko‘rib chiqildi va toifalarga ajratildi. Bunga ko‘ra A-tabiiy va texnogen omillar va B-subyektiv omillar. Binolarning 70% dan ortig‘i 1960–1990 yillarda qurilgan bo‘lib, fizik va ma’naviy eskirmoqda. Fizik eskirish omillariga quyidagilar kiradi: yemirilish, namlik, quyosh ta’siri. Ma’naviy eskirish esa eski muhandislik tizimlari (isitish, shamollatish), zamonaviy energiya tejoychi texnologiyalarning yo‘qligi va binolarning funksional jihatdan eskirishi bilan bog‘liq. Bu omillar issiqlik yo‘qotishlarini 35–50% ga oshiradi va energiya auditori, zamonaviy izolyatsiya materiallari va rekonstruksiya orqali energiya sarfini 20–40% ga kamaytirish mumkin.



1-rasm. KKUlarining energiya samaradorligiga ta’sir ko‘rsatuvchi omillar sxemasi.

Ushbu bob KKUlarining energiya samaradorligini baholash va oshirish bo‘yicha nazariy asoslarni umumlashtirdi, bu keyingi amaliy tadqiqotlar uchun muhim asos bo‘lib xizmat qiladi.

Dissertatsiyaning “Ko‘p kvartirali uylarning energiya samaradorligini eksperimental tadqiq etish” deb nomlangan uchinchi bobida eksperimental tadqiqotlarning vazifalari, sinov qurilmalari, vositalari va o‘lchov asboblari, sinov natijalari keltirilgan.

a)



b)



2-rasm. Tadqiqot obyektlari. a) Farg‘ona sh., Farg‘ona ko‘chasidagi 78-uy (yirik panelli);

b) Farg‘ona sh., Neftchilar ko‘chasidagi 26-uy (g‘ishtli).

Ushbu bobda Farg‘ona viloyatidagi ko‘p kvartirali uylar (KKU) ning energiya samaradorligi eksperimental tadqiq etildi. Tadqiqotda obyektlarning umumiy xususiyatlari, naturaviy sinov ishlari, mavjud energiya samaradorligi holati va issiqlik yo‘qotishlarining hisob-kitoblari ko‘rib chiqildi.

Tadqiqot obyekti sifatida Farg‘ona shahridagi ikki KKU – Farg‘ona ko‘chasi, 78-uy (4 qavatli temirbeton panelli, 1973 yilda qurilgan) va Neftchilar ko‘chasi, 26-uy (2 qavatli g‘ishtli) tanlandi.

1-tadqiqot obyekti tashqi to‘siq konstruksiyalarining mustahkamligi instrumental o‘rganildi. O‘rganish natijasida 1-tadqiqot obyektining tashqi devor panellari, poydevor panellarining o‘rtacha beton sinfi B20 ekanligi, ba’zi konstruksiyalarda namlik ta’sirida yemirilish holatlari mavjudligi, aniqlandi.

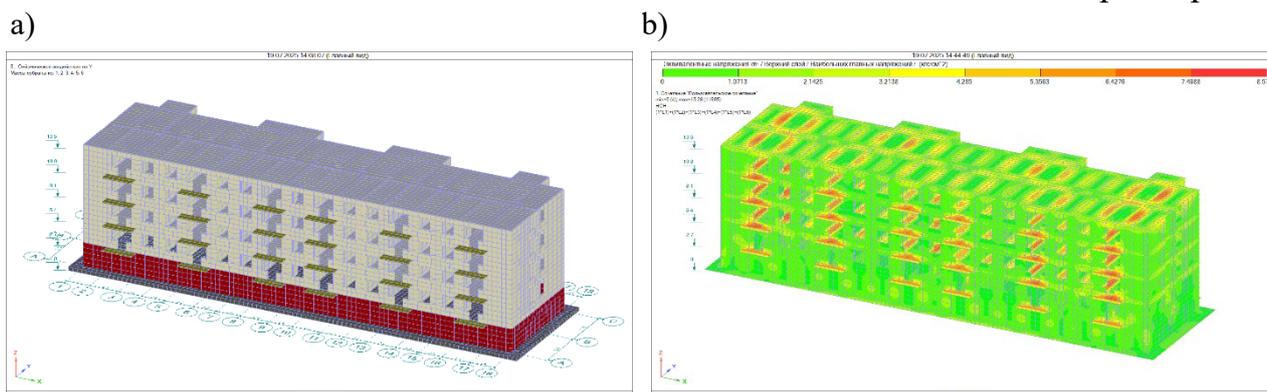
Binoning zilzilabardoshlilik darajasini baholash maqsadida LIRA-SOFT 10.12 hisoblash dasturi yordamida uning konstruktiv tizimi modellashtirilib, seysmik tahlil amalga oshirildi. Olib borilgan tahlillar natijasida bino konstruksiyasi seysmik ta’sirlarga nisbatan yetarlicha barqaror ekani aniqlandi.



3-rasm. Farg‘ona shahri, Farg‘ona ko‘chasidagi 78-uy konstruksiyalarini instrumental tekshirish. a) devor paneli beton sinfini aniqlash; b) Pulsar-2.2 qurilmasi natijasi.

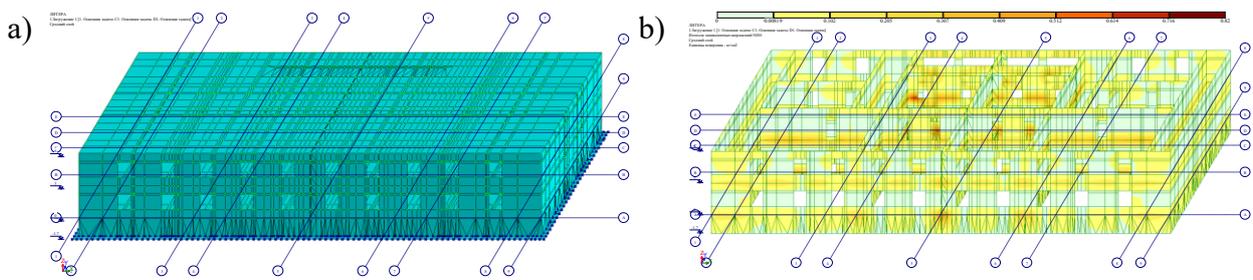
Neftchilar ko‘chasi 26-uyning poydevor, devor, yopmalar va tom konstruksiyalari texnik holati baholandi. G‘isht markasi laboratoriya sharoitida aniqlandi.

Sinov natijalariga ko‘ra, g‘ishtlarning o‘rtacha siqilishdagi mustahkamlik qiymati 5.00 MPa ni tashkil etdi. Bu natija O‘zDSt 3255:2017 standartiga muvofiq M50 markali g‘isht hisoblanib, past markali g‘isht hisoblanadi. Ushbu ma’lumot bino konstruktiv tizimlarini “LIRA-SAPR” dasturida hisoblashda asos sifatida qabul qilindi.



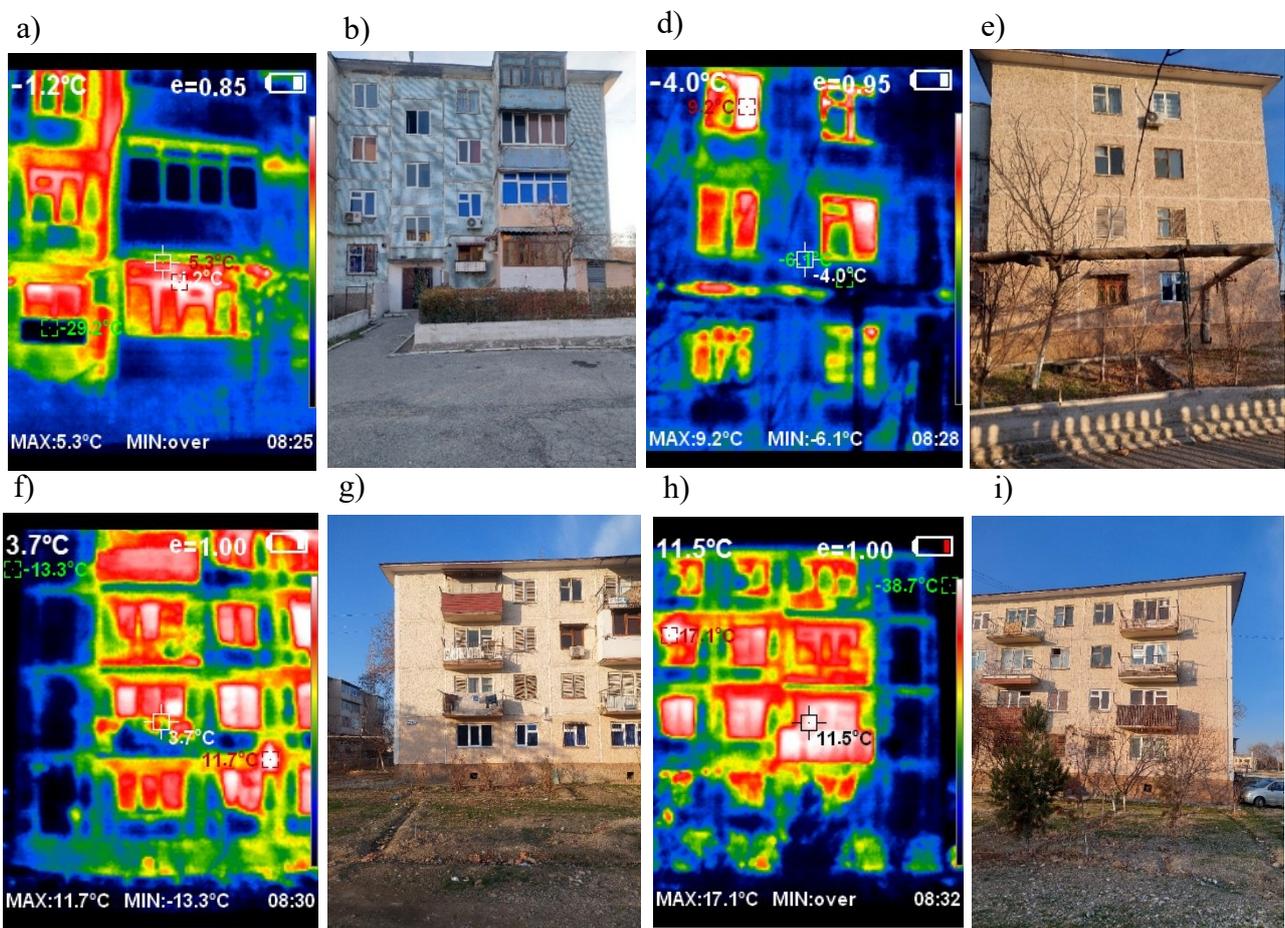
4-rasm. Yirik panelli binoning uch o‘lchamli modeli (a) va binoning zilzila ta’sirida konstruksiyalardagi ekvivalent kuchlanishlari (b).

ShNQ 1.04.03-23 ga asosan binoning konstruktiv elementlari xizmat muddatini o‘tagan. Hozirgi holatgacha kapital ta’mirlanmagan. Binoning haqiqiy ekspluatatsiya muddati 68 yilligini va bu turdagi binolar uchun me’yoriy ekspluatatsiya muddati 80-90 yilligini inobatga olib ushbu binoni kapital ta’mirlash xarajatlari o‘zini oqlash potentsiali past deb baholandi.



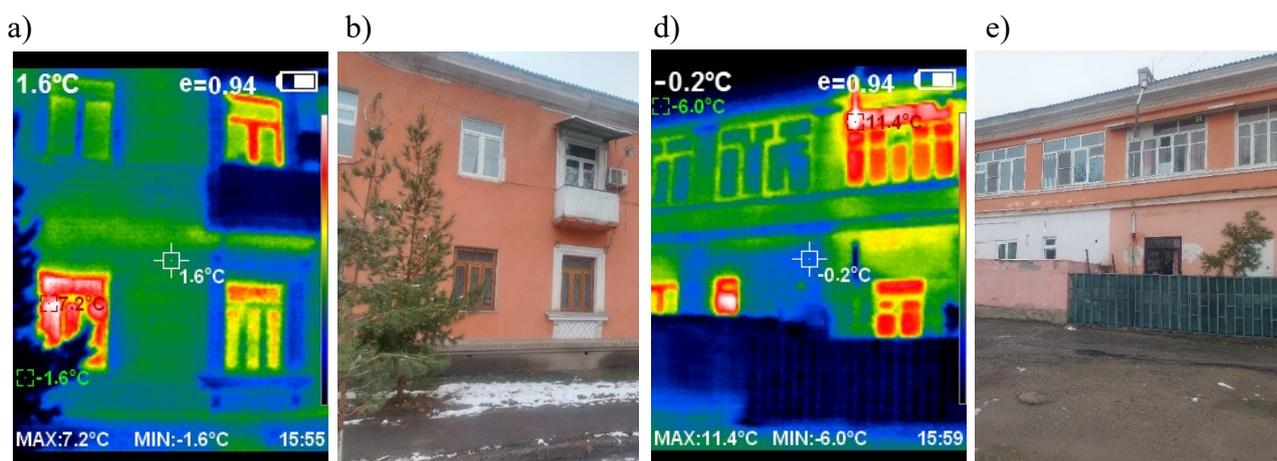
5-rasm. G'ishtli binoning uch o'lchamli modeli analitik holati (a) va binoning zilzila ta'sirida konstruksiyalardagi ekvivalent kuchlanishlari (b).

Bino konstruktiv va ma'naviy eskirgan deb topildi. Bunday binolarni kapital ta'mirlash emas, balki renovatsiya ishlarini amalga oshirish ko'proq samara beradi. Shu sababdan mavjud holatda binoga energiya samaradorlikka qaratilgan kapital ta'mirlash ishlarini olib borish maqsadga muvofiq emasligi aniqlandi.



6-rasm. 1-tadqiqot obyektining teplovizion tasvirlari (a,d,f,h) va fototasvirlar (b,e,g,i).

Farg'ona ko'chasi, 78-uy va Neftchilar ko'chasi, 26-uyning issiqlik yo'qotilishi UNI-T UTi260B teplovizori yordamida tahlil qilindi. Panelli binoda issiqlik yo'qotishlari panel bo'g'inlari, temirbeton o'zak qismlarida deraza perimetrlari va yopmalar bilan tutashuvlarda yuqori. G'ishtli binoda deraza birikmalari va orayopma plitalarda issiqlik chiqishi ko'p. Tasvirlarda past haroratli (ko'k) hududlar issiqlik yo'qotilishi kamligini va yuqori haroratli (qizil) zonalar issiqlik oqimini yuqori ekanligini ko'rsatdi.



7-rasm. 2-tadqiqot obyektining teplovizion tasvirlari (a,d) va fototasvirlar (b,e)

Isitish mavsumida binodan asosan tashqi devor konstruksiyalaridan va ventilyatsiya orqali issiqlik yo‘qotiladi va hisobiy issiqlik ajralishlar hisoblanadi, ya’ni:

$$Q_{\text{umumiy}} = \sum Q_{\text{konstr.}} + Q_{\text{vent}} - Q_{\text{is.ajr.}} \quad (1)$$

bu yerda:

$Q_{\text{konstr.}}$ – binoning tashqi to‘siq konstruksiyalaridan yo‘qotilayotgan issiqlik miqdori, Vt;

Q_{vent} – ventilyatsiyadan yo‘qotilayotgan issiqlik miqdori, Vt;

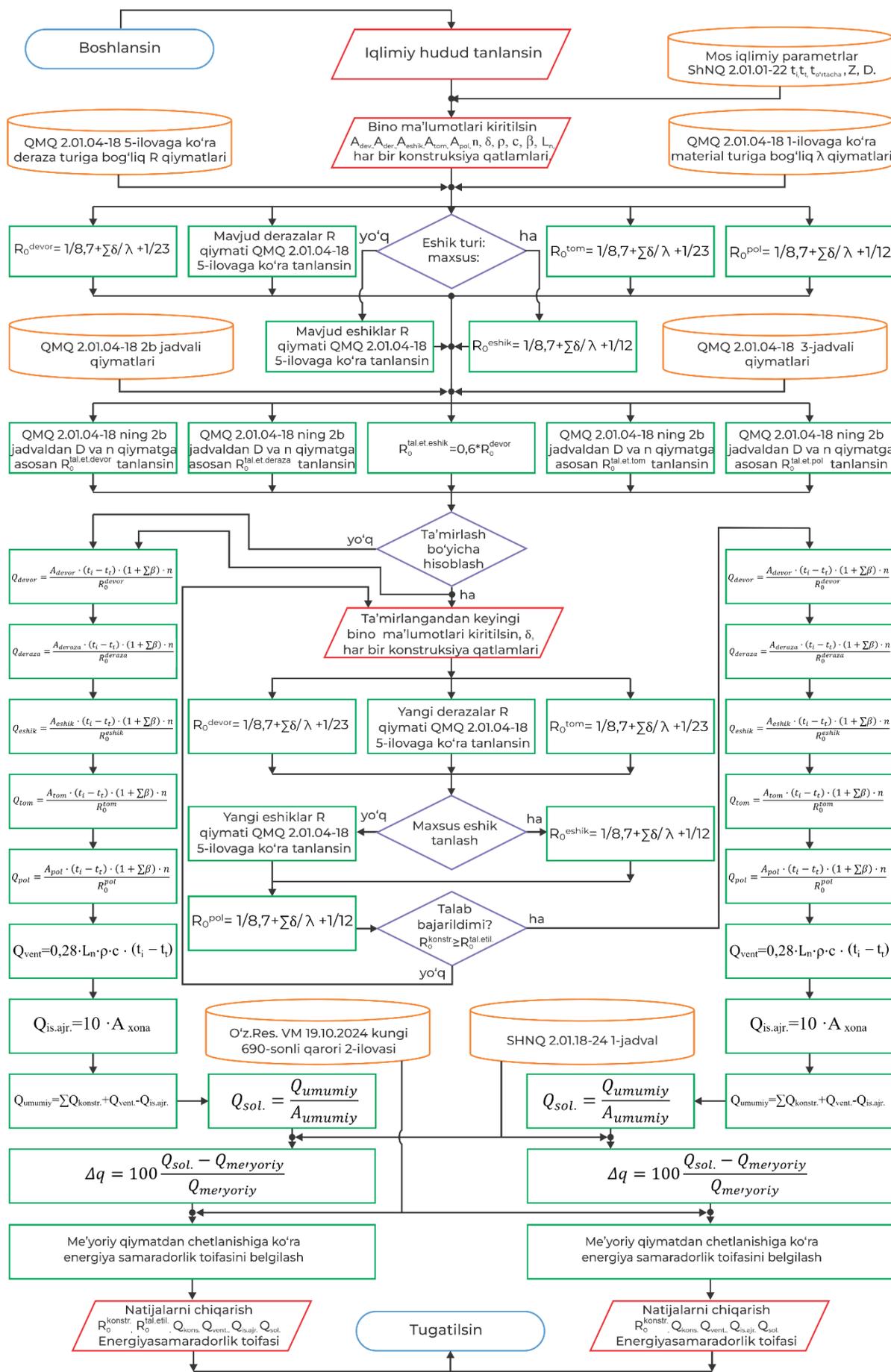
$Q_{\text{is.ajr.}}$ – hisobiy issiqlik ajralishlari, Vt.

Farg‘ona ko‘chasi, 78-uyning energiya samaradorligi hisoblandi. Tashqi devor ($R_0=0,89 \text{ m}^2 \cdot \text{C}/\text{Vt}$), deraza ($R_0=0,22 \text{ m}^2 \cdot \text{C}/\text{Vt}$), eshik ($R_0=0,16 \text{ m}^2 \cdot \text{C}/\text{Vt}$), tom ($R_0=1,56 \text{ m}^2 \cdot \text{C}/\text{Vt}$) va yerto‘la yopmasi ($R_0=0,60 \text{ m}^2 \cdot \text{C}/\text{Vt}$) ning termik qarshiligi me‘yoriy ko‘rsatkichlardan (2,2; 0,53; 0,59; 3,0; 1,96 $\text{m}^2 \cdot \text{C}/\text{Vt}$) sezilarli past. Umumiy issiqlik yo‘qotishlari 164,791 Vt, solishtirma issiqlik sarfi 83,7 Vt/ m^2 ni tashkil etdi, bu me‘yoriy ko‘rsatkichdan (57 Vt/ m^2) 46,8% yuqori. Bino energiya samaradorligi “G” toifasiga mos bo‘lib, bu energiya samaradorlikni oshirishga qaratilgan kapital ta‘mirlash ishlari zaruriyatini ko‘rsatadi.

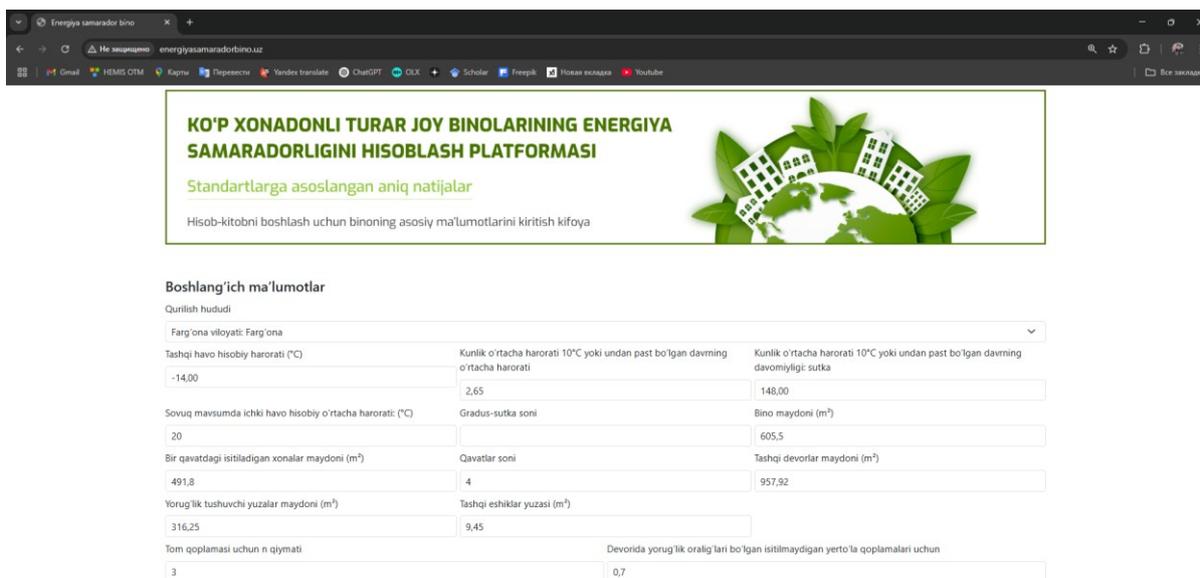
Tadqiqotda binolar texnik ko‘rikdan o‘tkazilish va energiya samaradorligini baholash ishlari birgalikda amalga oshirilishi binoning ma‘lumotlarini yig‘ishda, chizmalarini ishlab chiqishida, instrumental-texnik izlanishlar umumlashishini hisobiga mehnat va vaqt resurslari o‘rtacha 20 % ga qisqarishi asoslandi.

Ushbu bob KKUlarining energiya samaradorligini eksperimental tadqiq etish va ularni modernizatsiya qilish uchun amaliy tavsiyalar ishlab chiqishga asos yaratdi.

Dissertatsiyaning “**Ko‘p kvartirali uylarning energiya samaradorligini oshirish bo‘yicha tavsiyalar**” deb nomlangan to‘rtinchi bobida ko‘p kvartirali uylarning energiya samaradorligini hisoblashning hududning iqlimiy xususiyatlarini inobatga olgan holda baholash algoritmi ishlab chiqildi va shu algoritm asosida energiyasamaradorbino.uz hisoblash platformasi yaratildi. Platforma O‘zbekistonning turli iqlimiy hududlari uchun shaharsozlik normalari va qoidalariga moslashtirilgan, mavjud va modernizatsiya qilinayotgan binolarning energiya sarfini hisoblovchi va tejamkorlik potensialini aniqlovchi interaktiv veb-dasturiy ta‘minot hisoblanadi. Natijada muhandislar va loyihachilar uchun murakkab issiqlik texnikasi hisob-kitoblarini avtomatlashtirish orqali qaror qabul qilish jarayonini tezlashtirish va soddalashtirishga erishish ko‘zlangan.



8-rasm. Ko'p kvartirali uylarning energiya samaradorligini baholash platformasining ishlash algoritmi blok sxemasi.



9-rasm. Platforma bosh sahifasi

Platformaga asosiy bino parametrlarini kiritish orqali bino konstruksiyalarining issiqlik o'tkazishga bo'lgan qarshiligini, yo'qalayotgan issiqlik sarfini va bino energetik sinfini avtomatik hisoblash imkoniyatini beradi.

2-jadval

Tadqiqot obyekti konstruksiyalari R_0 qiymatlarining talab etilgan daraja bilan tafovuti.

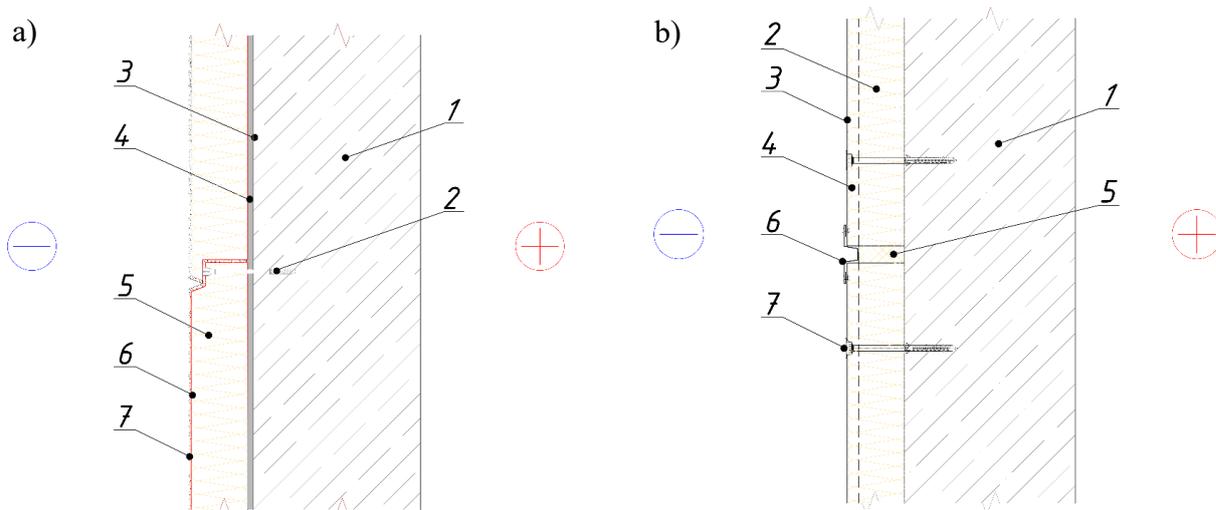
№	Konstruksiyalar nomi	$R_0, m^2 \times ^\circ C / Vt$	$R_0^{tal.et}, m^2 \times ^\circ C / Vt$	Me'yoriy qiymatdan chetlashishi, $m^2 \times ^\circ C / Vt$
1	Tashqi devor	0,89	2,20	-1,31
2	Deraza	0,22	0,53	-0,31
3	Eshik	0,16	0,59	-0,43
4	Tom yopmasi	1,56	3,00	-1,44
5	Pol	0,60	1,96	-1,36

Kelib chiqayotgan salbiy farqni qoplash uchun binoga izolyatsiya ishlarini amalga oshirish talab etiladi.

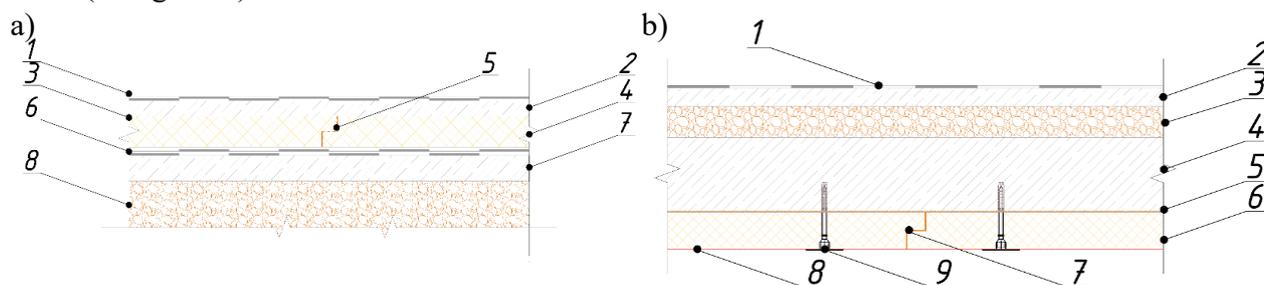
Konstruksiyalar issiqlik samaradorligini oshirish uchun 4 ta fasad izolatsiya tizimi tahlili amalga oshirildi. 1-nam fasad tizimi, 2- ventilyatsiyali fasad tizimi va taklif etilayotgan 3 -temopanel hamda 4-ventilyatsiyali termopanel tizimlar bo'lib, quyida 3 va 4-tizimlarning sxemasi batafsil ifodalangan.

Bino tom va pol qismlari uchun issiqlik izolyatsiyalash tizimlari sxemasi taklif etildi. Bunga ko'ra asosiy issiqlik izolyatsiyalovchi material sifatida ekstruziyalangan penopolistrol (XPS panel) materiali tanlab olindi. Bu material yengil va issiqlik o'tkazuvchanligi past, samarali issiqlik himoya materiali hisoblanadi. Pol qismi izolatsiyasida bino yerto'la qismidan 1-qavat yopmasi ostki qismidan izolyatsiyalash taklif etildi, sababi bunda xonadonlarda pol qoplamalarini almashtirish va xona balandligi o'zgarishidan saqlab qolishga erishish nazarda tutilgan.

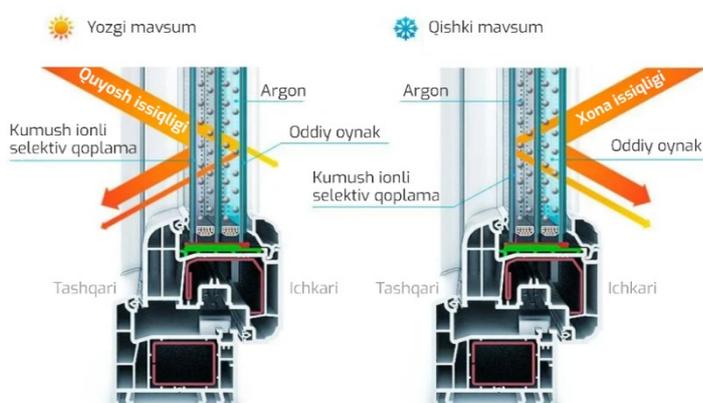
Tashqi derazalarni energiya samarador ichki issiqlikni saqlovchi selektiv qoplamali 2 kamerali deraza romlariga, tashqi eshiklar ichki qismida bazalt asosidagi mineral paxta qatlami bo'lgan energiya samarador eshiklarga almashtirilishi taklif etildi.



10-rasm. Tashqi devor issiqlik himoya tizimlari. a) termopanel; 1-devor; 2-plitani mahkamlash dubeli (1 m² ga 8 ta); 3-gruntovka; 4-polimersementli yelim (10mm); 5- mineral paxta plitasi (100mm); 6- yelimgan bazalt to'ri (8x8mm); 7-kvars qumi va polimer yelim asosidagi tashqi dekorativ qoplama (5 mm); b) ventilyatsiyali termopanel; 1-yuk ko'taruvchi devor; 2- bazalt asosidagi mineral paxta plitasi (100mm); 3-metall list qoplama; 4-havo oqimi uchun bo'shliq; 5- mineral momiq asosidagi oraliq qatlam; 6-panellar chokini yopish va havo oqimini tashkil etish uchun teshiklari mavjud bo'lgan metall listli qoplama; 7- panelni mahkamlash uchun komplekt mahkamlash dubeli (1m² ga 4 ta).



11-rasm. Tom va pol izolyatsiyalash sxemalari. a) tom izolyatsiyalash qatlamlari. 1-ikki qavat gidroizolatsion qoplama (Техноэласт ЭПП+Техноэласт К ТКП); 2-sement-qum asosidagi qorishma (30 mm); 3-namdan himoyalovchi polietilen qoplama; 4- XPS panel (60 mm); 5-montaj pena yelimi yordamida yelimlash; 6- mavjud gidroizolatsiya; 7- mavjud beton qatlami, 8-mavjud keramzit. b) pol izolyatsiyasi o'rnatish sxemasi. 1-mavjud lenolium; 2-sement-qum asosidagi qorishma (30 mm); 3-keramzit; 4-mavjud orayopma plitasi; 5-montaj pena yelimi yordamida yelimlash; 6-XPS panel 60-80 mm (Пеноплекс); 7- montaj pena yelimi yordamida yelimlash; 8- namlikdan himoyalovchi plyonka; 9- mahkamlash dubeli (1m² ga 8 ta).

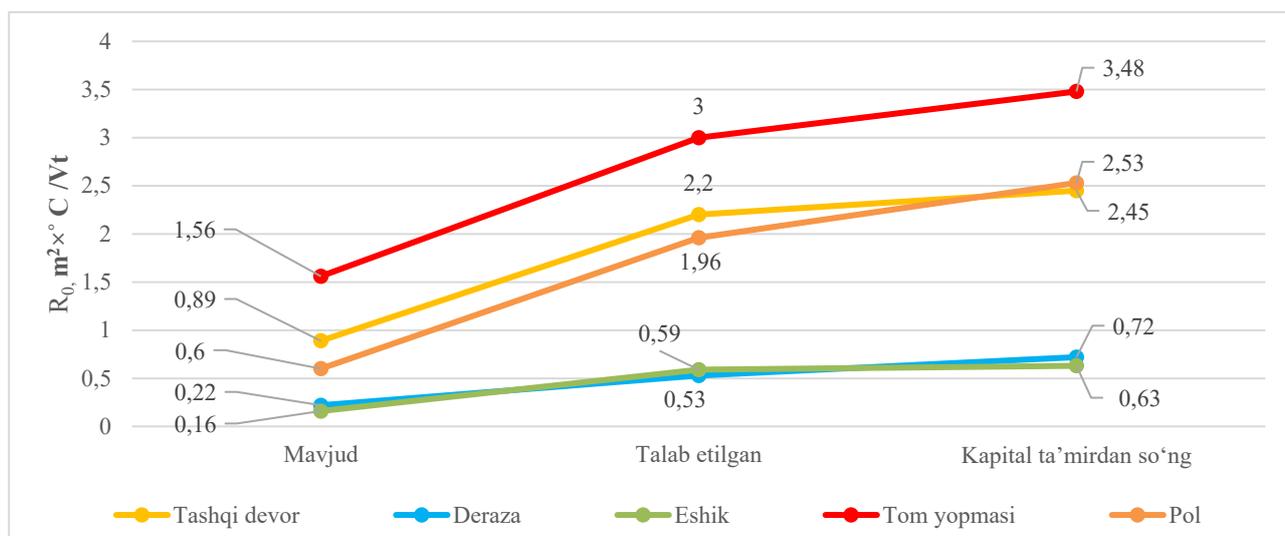


12-rasm. Ikki kamerali energiya samarador deraza romlari yozda va qishda ishlashi



13-rasm. Zamonaviy kirish yo'lagi eshigining bazaltli ichki qatlami.

Yuqoridagi tavsiya etilayotgan usullarda bino tashqi konstruksiyalarida R_0 qarshiliklar issiqlik himoyasining 2-darajasiga erishish imkonini beradi.



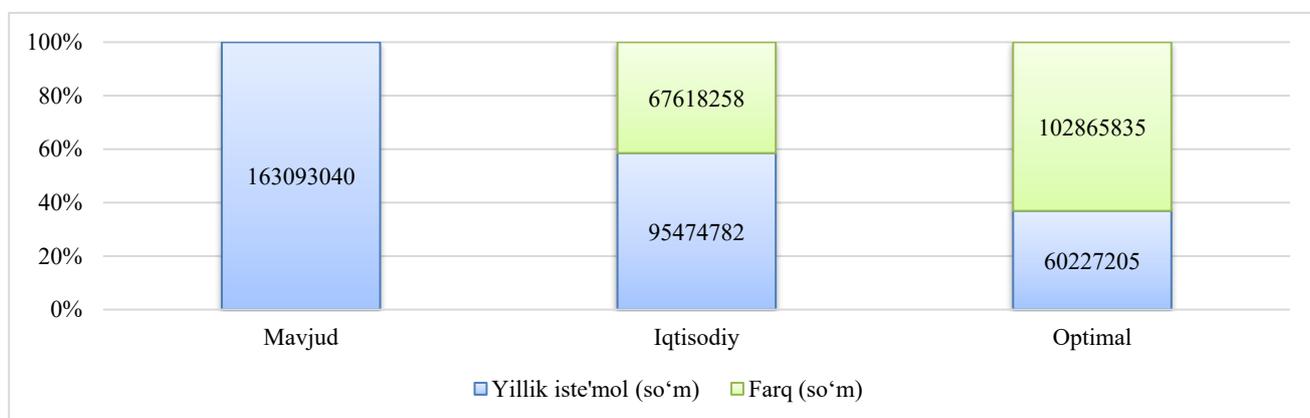
14-rasm. Konstruksiyalar R_0 qiymatining kapital ta'mirdan so'ng o'zgarish diagrammasi.

Kapital ta'mirlash xarajatlaridan kelib chiqib bino kapital ta'mirlashning yuqorida ko'rsatilgan barcha konstruksiyalar issiqlik izolatsiyasi choralarini qamrab olgan "Optimal" va tashqi derazalar almashtirilishi nazarda tutilmagan "Iqtisodiy" usullari taklif etildi.

3-jadval

Jami issiqlik yo'qotilishi va ajralishlari yig'indisi

№	Holati	Konstruksiyalardan issiqlik yo'qotilishi, Vt.	Ventilyatsiyadan issiqlik yo'qotilishi, Vt.	Hisobiy issiqlik ajralishi, Vt.	Jami, Vt.	Solishtirma issiqlik sarfi Vt/m ²	Energetik sinfi
1	Mavjud	131 866	46 495	13 570	164 791	83,70	G
2	Optimal	42 153			75 078	38,16	B
3	Iqtisodiy	78 557			111 482	56,67	D

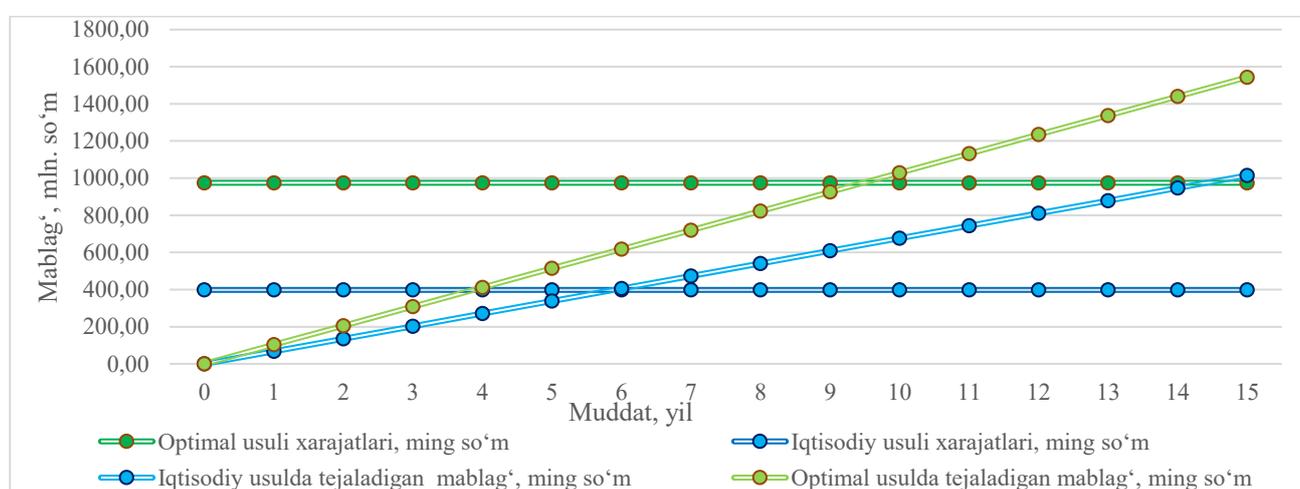


15-rasm. "Optimal" va "Iqtisodiy" usulda ta'mirlanganda kutiladigan energiya sarfi narxlarining mavjud holatdagi yillik energiya xarajatlardan farqi.

Umumiy xarajatlar miqdori taqqoslanishi

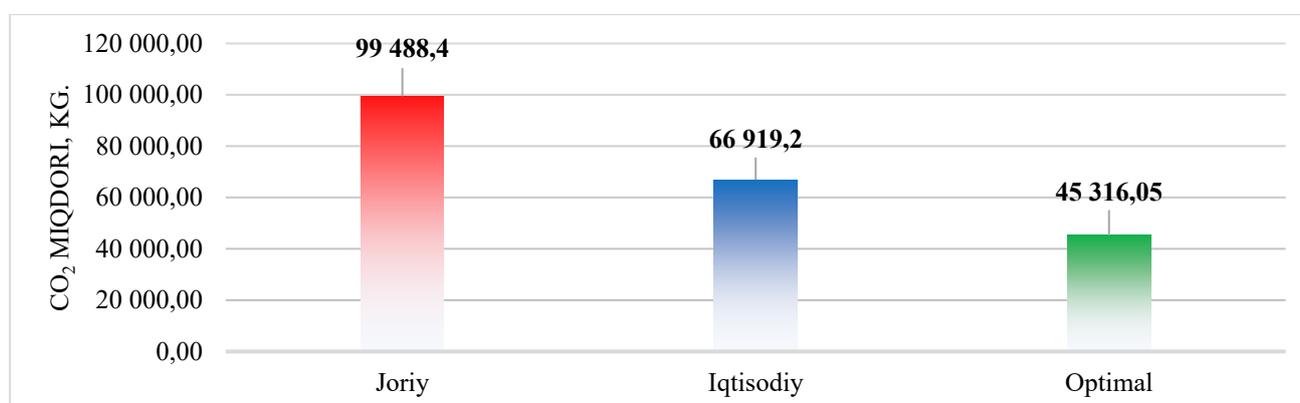
№	Tashqi devor izolyatsiyasi turi	Jami kapital ta'mirlash xarajatlari, so'm	
		Iqtisodiy	Optimal
1	Nam fasad tizimi	398 359 208	975 054 108
2	Ventilyatsiyali fasad tizimi	555 531 226	1 132 226 126
3	Termopanel	519 763 512	1 096 458 412
4	Ventilyatsiyali termopanel	516 853 344	1 093 548 244

Bino mavjud holatdagi va energetik samaradorligi o'zgargandagi isitish va sovutishga ketadigan sarf xarajatlar orasidagi tafovut iqtisodiy tahlil qilindi. Yillik harajatlar kamayishi hisobiga bino "Optimal" usulda ta'mirlanganda 975,05 mln. so'm ta'mirlash xarajatlarni 9,5 yilda, "Iqtisodiy" usulda kapital ta'mirlangandagi 398,36 mln. so'mni 5,9 yilda o'zini qoplashi asoslandi.



16-rasm. Kapital ta'mirlash xarajatlarning o'zini qoplash muddati diagrammasi.

Energiya sarfi kamayishi hisobiga atmosferaga ajraladigan CO₂ miqdori kamayishi hisoblandi.



17-rasm. Binoning mavjud holati va kapital ta'mirlashdagi CO₂ ajralishlari.

Kapital ta'mirlash binolarning holatini tiklash bilan birga energiya samaradorligini oshiradi, yashash sharoitlari va infratuzilmani yaxshilaydi va ekologik ta'sirni kamaytiradi.

XULOSALAR

“Ekspluatatsiyadagi ko‘p kvartirali uylarning energiya samaradorligini baholash va oshirish masalalari” mavzusidagi doktorlik (PhD) dissertatsiyasi bo‘yicha bajarilgan eksperimental-nazariy tadqiqot natijalari asosida quyidagi umumiy xulosalar chiqarildi:

1. Farg‘ona shahridagi KKUlarning katta qismi 1960–1990-yillarda qurilgan bo‘lib, ularning konstruktiv va muhandislik tizimlari jiddiy eskirgani aniqlandi. Qirguli mavzesida uylarning asosiy qismi 1-464a seriyali, 4 qavatli panelli uylar tashkil etib, aholining oshxona gaz plitasi, elektr isitgich kabi samarasiz va havfli isitish vositalaridan keng foydalanayotgani ma‘lum bo‘ldi.

2. Ko‘p kvartirali uylarning energiya samaradorligiga ta‘sir qiluvchi regional omillar A - tabiiy va texnogen omillar hamda B-subyektiv omillar guruhlariga ajratilib tizimli tahlil qilindi.

3. Qirguli mavzesidagi 4 qavatli panelli bino va 2 qavatli g‘ishtli bino texnik ko‘rikdan o‘tkazilishi, hamda LIRA-SAPR 10.12 dasturida 3D modellashtirish orqali panel bino seysmik yuklamalarga bardoshli, g‘ishtli bino esa konstruksiyalarida yuqori kuchlanishlar tufayli barqaror emasligi sababli yirik panelli binolar kapital ta‘mirlashga, g‘ishtli binolar esa renovatsiyaga muhtojligi asoslandi.

4. Farg‘ona shahridagi 4 qavatli panel (1-464a) va 2 qavatli g‘ishtli (1-204) binolar, issiqlik yo‘qotishlari panel bo‘g‘inlari, deraza-eshik perimetrlari, tom va pol zonalarida yuqori ekani teplovizor (UNI-T UTi260B) yordamida aniqlandi.

5. Ko‘p kvartirali uylarning texnik holatini instrumental-texnik tekshirish va energiya samaradorligini baholash ishlarini birgalikda amalga oshirish orqali mehnat hamda vaqt resurslarini 20% ga kamayishi nazariy jihatdan aniqlandi.

6. Panel binoda tashqi konstruksiyalarning termik qarshiligi (R_0) me‘yoriy talablardan past (tashqi devor: -59,55%, deraza: -58,49%, eshik: -72,88%). Umumiy issiqlik yo‘qotilishi 164 791 Vt, solishtirma sarf 83,7 Vt/m² (me‘yor: 57 Vt/m²), bu esa bino energetik sinfi “G” toifaga mansubligini ko‘rsatdi.

7. O‘zbekiston iqlimiy hududlariga moslashtirilgan energiyasamaradorbino.uz veb-platformasi (MVC, PHP, MySQL) hisob-kitob vaqtini 2–3 soatdan 10–12 daqiqaga qisqartirib, energiya pasportlarini shakllantirish va modernizatsiya choralari iqtisodiy asoslashni soddalashtirdi.

8. Bazalt asosli mineral paxta (100 mm) va ekstruziyalangan penopolistirol (XPS, 60 mm) qo‘llanilishi issiqlik yo‘qotishlarini 32–54% kamaytirib, me‘yoriy R_0 qiymatlarini ta‘minlaydi va energiya samaradorligini 25–40% oshirib bino energetik sinfini B toifaga o‘zgartirish potentsiali isbotlandi.

9. Ko‘p kvartirali uylarning tashqi devorlari izolyatsiyasida ventilyatsiyali fasad panellari ventilyatsiyali fasadga nisbatan montajda vaqt va ishchi kuchi xarajatlarining kamayishi hisobiga 1,1 barobar iqtisodiy samaradorligi isbotlandi.

10. “Optimal” ta‘mirlash (975 mln so‘m) energiya sarfini 298 424 kVt·s dan 137 635 kVt·s gacha, “Iqtisodiy” usul (398 mln so‘m) esa 202 066 kVt·s gacha kamaytiradi. Investitsiyalar 5,9–9,5 yilda qoplanishi hamda yillik CO₂ emissiyasi 32,5-54,2 (32,7%-54,5%) tonnagacha kamayishi asoslandi.

**SCIENTIFIC COUNCIL PhD.03/07.06.2024.T.106.06 AWARDDING THE
SCIENTIFIC DEGREES AT THE FERGANA STATE TECHNICAL
UNIVERSITY**

FERGANA STATE TECHNICAL UNIVERSITY

KHALIMOV ABBOSBEK OYBEK UGLI

**ISSUES OF ASSESSING AND IMPROVING ENERGY EFFICIENCY OF
OPERATING APARTMENT BUILDINGS**

05.09.01–Engineering constructions, buildings and structures

ABSTRACT

Of the PhD dissertation technical sciences

Ferghana-2025

The theme of doctor of philosophy dissertation is registered by the Supreme Attestation Commission at the ministry of higher education, science and innovations of the Republic of Uzbekistan B2025.3.PhD/T5810

The doctoral dissertation (PhD) has been carried at Fergana State Technical University.

Dissertation abstract in three languages (Uzbek, Russian, English (resume)) is available on the web page of the Scientific Council (www.fstu.uz) and on the Information and Educational Portal (www.ziyonet.uz).

Scientific supervisor:	Khotamov Asadulla Toshtemirovich doctor of technical sciences, professor
Official opponents:	Yuvmitov Anvar Sayfullayevich doctor of Technical Sciences, Senior Researcher
	Norov Nusiratjon Nuralievich Doctor of Philosophy in Technical Sciences, Associate Professor.
Lead organization:	Namangan State Technical University

Thesis defense will take place on “31” october 2025 at 14³⁰ at the meeting of the Scientific Council PhD.03/07.06.2024.T.106.06 at the Fergana State Technical University. (Address: Ferghana, 86 Ferghana st, Tel./fax (99873) 241–12–06, e- mail: info@fstu.uz)

The dissertation can be found at the Information Resource center of the Fergana State Technical University (registration number №296). (Address: Ferghana, 86 Ferghana st, Tel./fax (99873) 241–12–06, e- mail: fstuarm@edu.uz)

The dissertation abstract has been distributed “17” october 2025 of the year.
(Registration report №1/2025-7 dated “15” october 2025).

S.F. Ergashev

Chairman of the scientific council for awarding
scientific degrees, doctor of technical sciences, professor

Sh.A. Umarov

Scientific secretary of the scientific
council for the award of doctoral degrees
doctor of philosophy (PhD) on technical sciences, docent

Kh.A. Akramov

Deputy chairman of the scientific seminar at scientific council for
awarding academic degrees,
doctor of technical sciences, professor

INTRODUCTION (annotation of the dissertation of Doctor of Philosophy (PhD))

Relevance and demand of the dissertation topic. Due to the steady increase in global demand for energy resources, particular attention is being paid to improving energy efficiency in the design of modern buildings and in the process of major renovation of existing ones, as well as to the efficient use of energy consumed for heating. As of 2024, global energy demand has risen by 2.2%, reaching a total of 640×10^{18} joules (640 exajoules). Electricity consumption has grown especially significantly—by 4.3%—exceeding the growth rate of the global gross domestic product (3.2%). In 2024, electricity consumption in buildings reached a record level, accounting for 60% of total global consumption, which is associated with the growing need for heating and cooling. In this regard, the development of practical solutions aimed at enhancing the energy efficiency of buildings, ensuring the rational management of energy consumption, and promoting energy savings has become particularly relevant.

In global practice, large-scale scientific research is being carried out aimed at ensuring the energy efficiency of buildings. In these studies, priority is given to reducing the amount of energy lost through the external enclosing structures of buildings and improving the structures themselves. In developed countries, in particular the United States, Canada, Germany, Finland, Russia, China, and Japan, great experience has been accumulated in designing energy-efficient buildings and improving the energy efficiency of existing structures. In order to further improve the energy efficiency of buildings, new structural solutions are being developed and implemented in practice, including the improvement of methods for assessing building energy efficiency and methods for reducing the amount of heat loss through external enclosing structures, which is one of the urgent tasks.

In our Republic, in recent years, large-scale reforms have been implemented aimed at developing and practically applying new technologies that help to improve the energy efficiency of buildings. Tasks have been defined for “Conducting scientific research on green technologies”¹ and “Ensuring the introduction of the ‘Green Building’ certificate for newly constructed facilities and residential buildings based on their energy efficiency.”² In this regard, in particular, issues of further improving methods for determining and assessing the level of energy efficiency of multi-apartment buildings, as well as increasing the thermal protection indicators of buildings through the widespread implementation of advanced heat-insulating construction materials and innovative structural solutions, are of great scientific and practical importance.

The declaration of the year 2025 in the Republic of Uzbekistan as the “Year of Environmental Protection and the Green Economy,” as well as the Presidential Decree No. DP-60 of January 28, 2022 “On the Development Strategy of New Uzbekistan for

¹ Resolution of the President of the Republic of Uzbekistan No. RP-100 of March 11, 2025 “On measures for the fundamental reform of the housing and building heat supply sector and for improving the energy efficiency of buildings”

² Decree of the President of the Republic of Uzbekistan No. DP-16 of January 30, 2025 “On the state program for the implementation of the strategy “Uzbekistan — 2030” in the “Year of environmental protection and green economy”

2022–2026,” Presidential Decree No. DP-158 of September 11, 2023 “On the Uzbekistan–2030 Strategy,” Presidential Resolution No. RP-57 of February 16, 2023 “On measures to accelerate the introduction of renewable energy sources and energy-saving technologies in 2023,” and Presidential Resolution No. RP-100 of March 11, 2025 “On measures for the fundamental reform of the housing and building heat supply sector and for improving the energy efficiency of buildings,” together define the tasks whose implementation contributes to achieving the objectives set forth in the relevant regulatory and legal documents in this field. The present dissertation research, to a certain extent, makes its contribution to the implementation of these tasks and the attainment of the stated goals.

Compliance of the research with the priority areas of development of science and technology of the Republic of Uzbekistan. The dissertation has been carried out in accordance with Priority Area II — “Energy, Energy and Resource Efficiency” of the development of science and technology of the Republic of Uzbekistan.

Degree of study of the problem. Since the issue of energy efficiency is of global importance, continuous research is being conducted in this field. Studies on this topic have been carried out by foreign and CIS scientists such as R.M. Aloyan, S.V. Fedosov, L.A. Oparina, N.V. Pilipenko, Y.G. Kiseleva, M.S. Myagkova, A. Lari, V.M. Fokin, A. Galata, J.M. Andújar, S.G. Melgar, A.E. Kiryudcheva, D.O. Sovetnikov, P.V. Monastrev, A.M. Makarov, S.V. Kornienko, C. Costantino, A.C. Benedetti, R. Gulli, V. Milich, P. Rohdin, M. Upis, I. Amolina, I. Geipele, N. Zeltins, A. Papoyan, Ch. Jan, S. Han, G. Li, Zhang H., and several other researchers.

In the Republic of Uzbekistan, research in the field of energy efficiency of civil buildings has been conducted by M.M. Zokhidov, G.Sh. Shukurov, S.M. Makhmudov, and E.S. Tulakov on improving building energy efficiency; R.Y. Marakaev and N.N. Norov on the design of energy-efficient buildings under the conditions of Uzbekistan; J.V. Eshmurodov, Q. Edmurodov, S.A. Khodjaev, R.R. Qadirov, E.V. Shipacheva, and M. Nabiyev on designing energy-efficient buildings in dry and hot climates; and M.A. Koroli and M.B. Khudyarov in the field of building energy audits. Issues related to the optimal placement of buildings relative to the horizon and the influence of natural, technogenic, and anthropogenic factors on building energy efficiency in residential areas have been studied by I.S. Shukurov, A.T. Khotamov, Kh.F. Allaberganov and B.E. Dusatov.

Based on analytical indicators, it has been determined that the issue of assessing the energy efficiency of multi-apartment residential buildings has not yet been fully explored. Therefore, it is necessary to develop assessment methods that take into account the territorial and climatic conditions of the Republic of Uzbekistan.

Connection of the dissertation research with the research work plans of the higher educational or research institution where the dissertation was carried out. The dissertation research was carried out in accordance with the research work plan of the Fergana State Technical University within the framework of the project "Sustainability and Industrial Innovation Program." (2024-2025)

The aim of the research is to assess the energy efficiency of existing multi-apartment residential buildings and to identify methods for reducing heat losses

through external enclosing structures.

Research objectives:

to analyze scientific literature and practical studies related to the assessment and improvement of building energy efficiency;

to conduct monitoring of existing multi-apartment residential buildings located in the Qirguli district of Fergana city and identify the main problems associated with energy losses;

to determine the theoretical and methodological foundations for assessing the energy efficiency of multi-apartment residential buildings;

to develop an electronic platform that automates calculations for improving the methods of energy efficiency assessment of multi-apartment buildings;

to design constructive and technical solutions aimed at reducing heat losses through external enclosing structures of multi-apartment buildings;

to determine the practical value of the proposed solutions by evaluating their economic efficiency.

The object of the research consists of multi-apartment residential buildings currently in operation, located in the Qirguli district of Fergana city.

The subject of the research includes the energy efficiency of operating multi-apartment residential buildings, particularly the methodological and practical aspects aimed at assessing and improving their thermal protection level.

Research methods. The study employs methods of statistical analysis, evaluation, field inspections of real buildings, and comparative analysis.

The scientific novelty of the research is as follows:

the methodology for assessing the energy efficiency of multi-apartment residential buildings has been improved by developing an algorithm that takes into account changes in the thermal resistance of building structures after major renovation;

an online calculation platform has been developed, allowing for a comprehensive and rapid assessment of the energy efficiency of multi-apartment buildings and for upgrading their thermal energy class based on changes in the building's specific heat consumption;

it has been determined that an integrated approach combining instrumental and technical inspections of the technical condition of multi-apartment buildings with energy efficiency assessments reduces labor and time resources by 20%;

it has been proven that the use of facade panels as external wall insulation in multi-apartment buildings provides 1.1 times higher economic efficiency due to the simplified design of the panels and the mechanization of the installation process compared to ventilated facades.

The practical results of the research are as follows:

during the process of assessing the energy efficiency of multi-apartment buildings, the accuracy and reliability of the assessment were ensured by considering structural and technological changes after major repairs, and the methodological mechanism of evaluation was improved;

an automated online calculation platform, energiayasamardor-bino.uz, has been developed, which enables rapid computation of building energy efficiency and determination of their thermal energy class;

the integration of technical condition inspections and energy efficiency assessments of multi-apartment buildings created the opportunity for rational use of labor and time resources;

the technological processes of using ventilated facade panels for external wall insulation have been thoroughly studied, demonstrating that dry installation increases construction efficiency and substantiating the technological advantages of these systems.

Reliability of the research results. The theoretical calculations used in the course of the research are based on current construction standards and regulations. A comprehensive analysis of the factors influencing heat losses and their scientifically grounded systematization ensured the reliability of the obtained results. Furthermore, the results obtained through the developed online platform, operating on the basis of the designed calculation algorithms, are validated by their conformity with existing practical cases.

Scientific and practical significance of the research results. The scientific significance of the research results lies in the development of an online calculation algorithm and platform adapted to regional conditions for assessing the efficiency of thermal protection of operating multi-apartment residential buildings, as well as in the contribution to the theory of energy efficiency assessment through a scientifically grounded analysis of constructive solutions in terms of their thermal protection level.

The practical significance of the research results is defined by the development and recommendation of technically and economically feasible structural solutions aimed at improving the energy efficiency of the existing housing stock; the creation of an opportunity to assess building heat losses through the online platform energiyasamardorbino.uz; and the ability to preliminarily evaluate the effectiveness of renovation measures based on the obtained calculation results.

Implementation of the research results. Based on the scientific research results on the topic “Issues of assessing and improving energy efficiency of operating apartment buildings”:

The methodology for assessing the energy efficiency of multi-apartment buildings has been improved by developing an algorithm that accounts for changes in the thermal resistance of structures after major renovation. An online platform has been created that enables comprehensive and rapid assessment of a building’s energy efficiency and determination of its thermal energy class based on the variation in specific heat consumption. The proposals for applying this methodology were utilized by the design organization “Fargonafuqaroloyiha” LLC in the development of the project for a 7-storey residential building located on Khirmontepa Street, Sokh District (Reference No. 34–06/10251 dated September 10, 2025, issued by the Ministry of Construction and Housing and Communal Services of the Republic of Uzbekistan). As a result, the time spent on thermal engineering calculations was reduced by up to 25% compared to traditional methods.

The proposals for implementing an integrated approach combining the technical inspection and energy efficiency assessment of multi-apartment buildings, as well as the use of simplified facade panel structures for external wall insulation—allowing for reduced labor and installation time compared to ventilated facades and achieving 1.1

times higher economic efficiency—were applied by “Construction Test Laboratory” LLC during the construction of a 5-storey residential building on B. Marg‘iloniy Street, Marg‘ilon city (Reference No. 34–06/10251 dated September 10, 2025, issued by the Ministry of Construction and Housing and Communal Services of the Republic of Uzbekistan). As a result, the proposed methods achieved up to 10% economic efficiency.

Approbation of the research results. The results of the dissertation research were discussed at 8 international and 2 national scientific and practical conferences.

Publication of the research results. A total of 19 scientific papers have been published on the topic of the dissertation, including 6 articles in journals recommended by the Higher Attestation Commission of the Republic of Uzbekistan for the publication of key scientific results of PhD dissertations. Among them, 5 articles were published in national journals and 1 article in an international scientific journal.

Structure and scope of the dissertation. The dissertation consists of an introduction, four chapters, conclusions, a list of references, and appendices. The total volume of the dissertation is 120 pages.

MAIN CONTENT OF THE DISSERTATION

The introduction substantiates the relevance and necessity of the dissertation research, the compliance of the research with the priority areas for the development of science and technology of the republic, the goal and objectives of the research, the object and subject of research, the scientific novelty of the research, the scientific and practical significance of the results obtained, the implementation of the research results into production, information on the approbation of the research results, published scientific articles on the topic of the dissertation, as well as information on the structure and volume of the dissertation.

In the first chapter of the dissertation, entitled "**Energy saving in residential buildings and trends in their development in the city of Fergana,**" scientific and technical literature, domestic and foreign publications were analyzed, the current technical condition of apartment buildings (MAB) in the city of Fergana, energy efficiency, construction history, and problems related to their operation were analyzed in detail. The study examined global energy saving trends, the dynamics of housing stock development in Uzbekistan and, in particular, in the Fergana region, as well as the characteristics of technical and energy efficiency of residential buildings in the Kirguli district.

The historical and modern development of housing construction in Uzbekistan, in particular in the Fergana region, was analyzed. As of 2023, there are 47,776 MABs in the republic, of which about 9% are located in the Fergana region. In the city of Fergana, KKUs built in the 1960s-1990s prevail, during which reinforced concrete and brick structures were widely used. In the Fergana region, there are 4149 MABs, of which 1554 are located in the city of Fergana, in particular, 477 in the Kirguli massif. These bneedles are made of 61% reinforced concrete, 35.2% brick, and 3.1% wood. 4-story buildings (285 units) are most common, mainly panel houses of series 1-464a and 2-story brick houses .

Problems of operation and energy efficiency of MABs in the city of Fergana were considered. The engineering systems of most buildings are outdated, and the thermal

insulation does not meet the standards. 33% of the population uses gas stoves, 26% electric heaters, 14% air conditioners, and 13% water heating systems based on natural gas which increases energy consumption and fire risk . The problems are caused by insufficient funds for repairs, insufficient implementation of new technologies, and a low culture of energy conservation.

This chapter summarizes important data on the technical condition, energy efficiency, and the history of the development of MABs in the city of Fergana, which will serve as a basis for further research.

In the second chapter of the dissertation, entitled "**Factors Negatively Affecting Apartment Buildings and Theoretical Foundations for Assessing Energy Efficiency**" the concept of energy efficiency of apartment buildings, Uzbek and foreign experience in its assessment methodologies, as well as regional factors negatively affecting energy efficiency, were analyzed. The study examined the theoretical and practical aspects of increasing energy efficiency, modern approaches in construction, and their impact on environmental sustainability.

Energy efficiency issues of MAB have been thoroughly studied. Energy-efficient buildings are divided into two types: energy-efficient (reducing consumption through special architectural solutions) and energy-active (using alternative energy sources). The study emphasized the importance of the integration of thermal insulation materials, heating and cooling systems, ventilation, and modern technologies (for example, solar panels, LED lights). These elements will reduce energy consumption by 30-90%, ensure environmental sustainability, and improve living conditions. In the Republic of Uzbekistan, the energy efficiency of buildings is divided into seven categories, ranging from A to G, where A represents the highest level of energy efficiency and G the lowest. (Table 1).

Table 1

Schedule for determining the category of energy efficiency of buildings and structures

Energy efficiency category of buildings and structures	Amount of deviation, %	Suggestions
A 	- more than 40	Energy-efficient buildings and structures that can be economically stimulated
B 	-40 to -26	
C 	-25 to -11	
D 	-10 to +4	Normal consumption
E 	from +5 to +14	It is necessary to reduce heat losses in buildings and structures.
F 	from +15 to +25	
G 	More than +25	Requires major repairs or reconstruction of buildings and structures

Foreign experience was analyzed, in particular, the Energy Performance of Buildings Directive (EPBD), BREEAM and LEED systems. EPBD (2002, 2010, 2018, updated in 2024) aims to reduce energy consumption in Europe by 60% by 2030 and create a zero-carbon building stock by 2050. The BREEAM (1990) and LEED (1993) systems assess the building's energy efficiency, environmental sustainability, and

quality of the internal environment. BREEAM certificates range from "Outstanding" to "Unclassified," and LEED certificates range from "Platinum" to "Certified." These systems will reduce energy consumption by 30-50%, reduce carbon emissions, and improve living conditions.

Factors influencing the wear and tear of MABs in the Fergana region and their impact on energy efficiency were considered and categorized. Accordingly, 'A-natural and man-made factors and B-subjective factors. More than 70% of buildings were constructed in the 1960s and 1990s and are facing physical and obsolescence. Physical aging factors include: yeweathering, humidity, and sun exposure. Spiritual obsolescence is associated with the lack of old engineering systems (heating, ventilation), modern energy-saving technologies, and the functional deterioration of buildings. These factors increase heat losses by 35-50%, and energy consumption can be reduced by 20-40% through energy audits, modern insulation materials, and reconstruction.

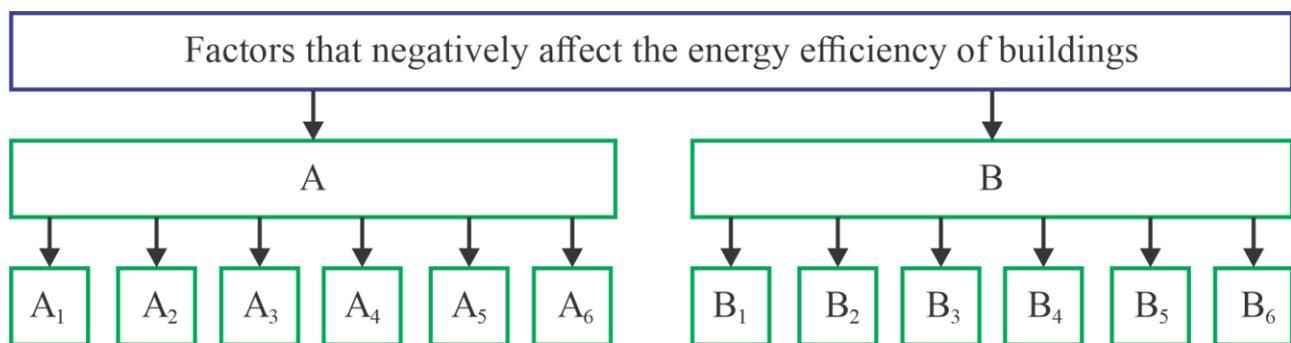


Figure 1. Diagram of factors influencing the energy efficiency of apartment buildings.

This chapter summarizes the theoretical foundations for assessing and increasing the energy efficiency of MABs, which will serve as an important basis for further practical research.

The third chapter of the dissertation, entitled "**Experimental Study of the Energy Efficiency of Apartment Buildings**", presents the tasks of experimental studies, test devices, instruments and measuring instruments, and test results.

a)



b)



Figure 2. Research objects. a) House 78 on Fergana Street, Fergana City (large-panel); b) House 26 on Neftchilar Street, Fergana City (brick).

In this chapter, the energy efficiency of apartment buildings in the Fergana region was experimentally investigated. The study examined the general characteristics of the objects, field tests, the current state of energy efficiency, and calculations of heat losses.

The objects of the study were two MABs in the city of Fergana - Fergana Street, house 78 (4-story reinforced concrete panel, built in 1973) and Neftchilar Street, house 26 (2-story brick).

The strength of the external barrier structures of the 1st object of research was studied instrumentally (Pulsar 2.2 and Schmidt). As a result of the study, it was established that the external wall panels of the 1st research object, the foundation panels are of the average concrete class B20, and in some structures, there are cases of wear under the influence of moisture.

In order to assess the level of seismic resistance of the building, its structural system was modeled using the LIRA-SOFT 10.12 calculation program and seismic analysis was performed. As a result of the analysis, it was established that the building structure is sufficiently resistant to seismic impacts.



Figure 3. The process of checking the structures of building 78 on Fergana Street in Fergana city using special equipment. a) checking the concrete grade of external wall panels; b) Pulsar-2.2 device result.

The technical condition of the foundations, walls, ceilings, and roof structures of building No. 26 on Neftchilar Street was assessed. The brick grade was determined under laboratory conditions.

According to the test results, the average compressive strength of the bricks was 5.00 MPa. This result, in accordance with the UzDSt 3255:2017 standard, is considered a brick of grade M50, which is considered a low-grade brick. This data was taken as a basis for calculating building structural systems in the "LIRA-SAPR" program.

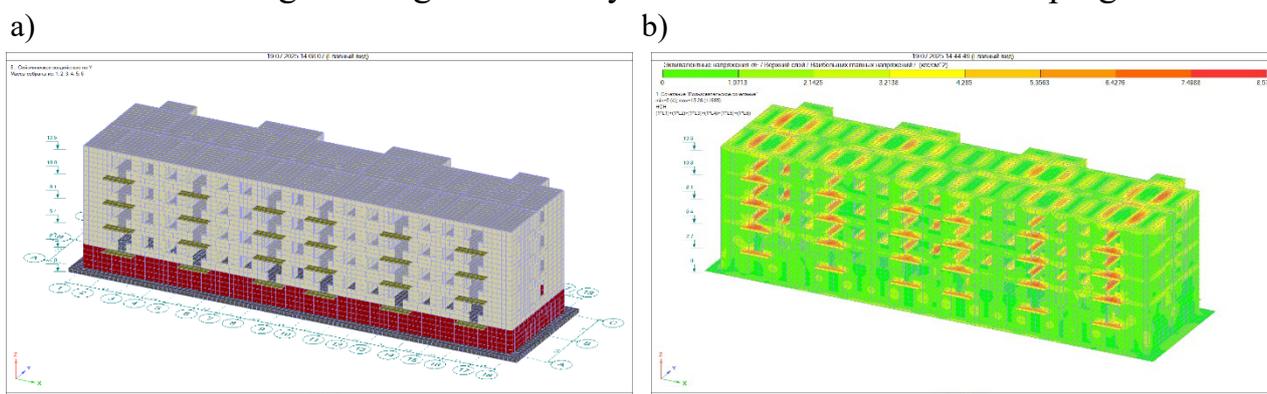


Figure 4. Three-dimensional model of a large-panel building (a) and equivalent stresses in the building's structures under earthquake action (b).

According to SHNK 1.04.03-23, the structural elements of the building have exceeded their service life. Until now, it has not undergone major repairs. Considering that the actual service life of the building is 68 years, and the standard service life for this type of building is 80-90 years, the potential for the cost of capital repairs of this

building is assessed as low.

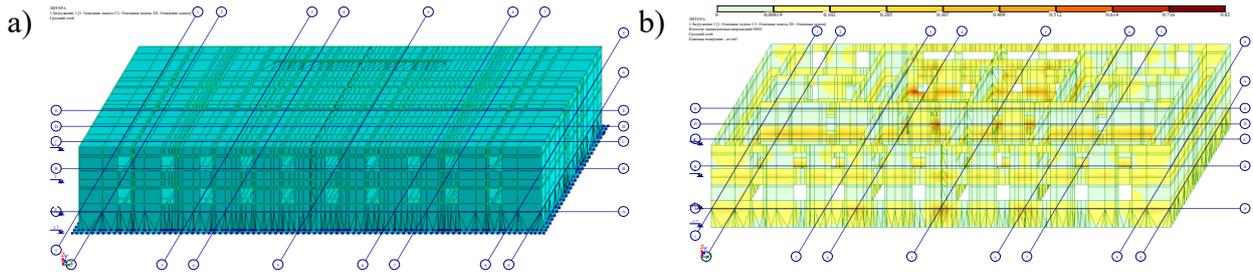


Figure 5. Analytical state of a three-dimensional model of a brick building (a) and equivalent stresses in the structures of the building under earthquake action (b).

The building was deemed structurally and morally obsolete. Carrying out renovation work instead of major repairs of such buildings will be more effective. For this reason, it was determined that in the current state, it is not advisable to carry out major repairs aimed at energy efficiency.

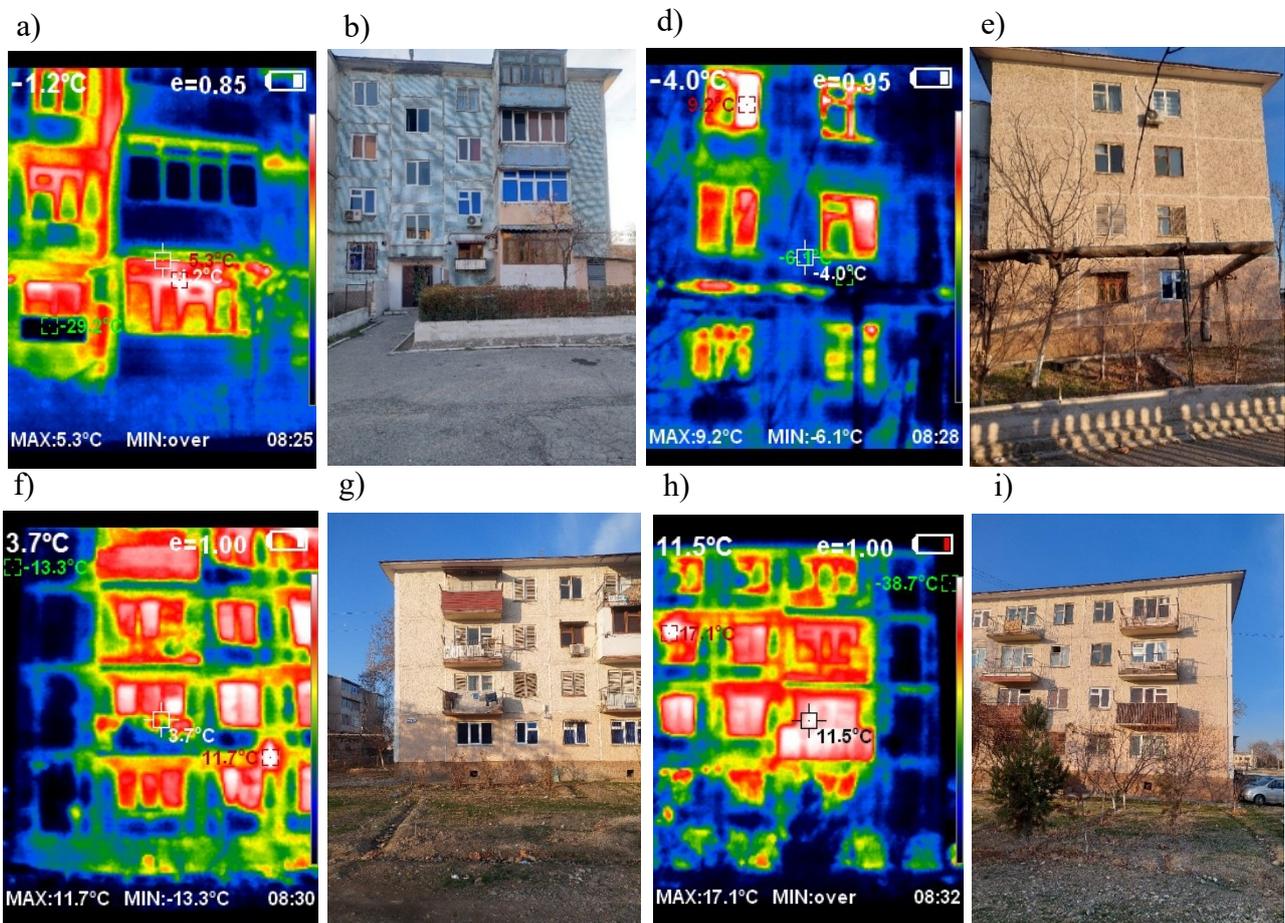


Figure 6. Thermal imaging (a,d,f,h) and photographic images (b,e,g,i) of the 1st object.

Heat losses were analyzed using the UNI-T UTi260B thermal imager Fergana Street, house 78 and Neftchilar Street, house 26. Heat losses in panel buildings are high in panel joints, reinforced concrete core parts, window perimeters, and joints with roofs. In a brick building, there is a lot of heat loss in window joints and floor slabs. In the images, the low-temperature (blue) zones showed low heat loss, and the high-temperature (red) zones showed high heat flow.

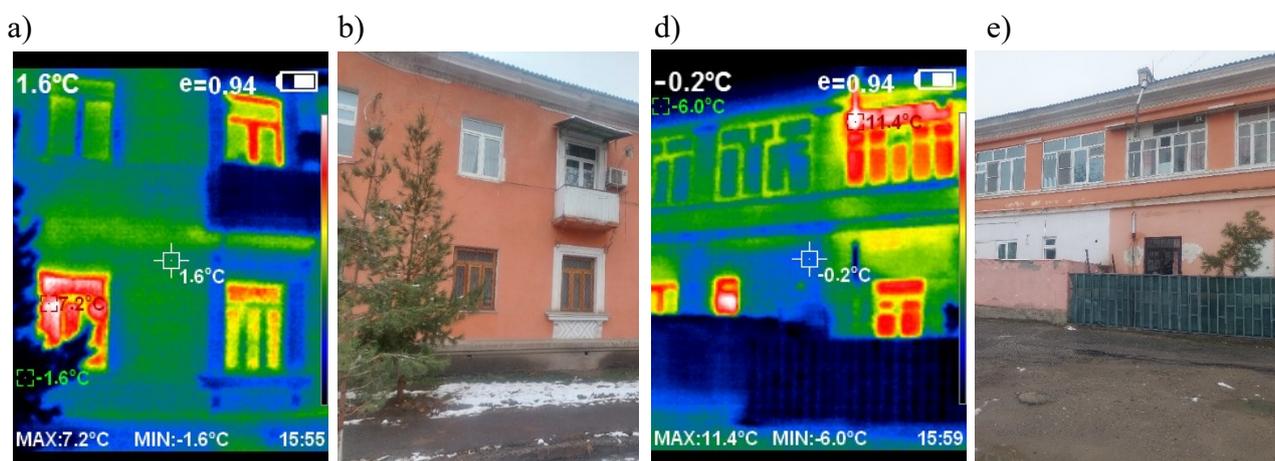


Figure 7. Thermal imaging (a,d) and photographic images (b,e) of the 2nd research object

During the heating season, heat is lost from the building mainly through external wall structures and ventilation, and the calculated heat releases are calculated:

$$Q_{\text{total}} = \sum Q_{\text{constr.}} + Q_{\text{vent}} - Q_{\text{ht.dis.}} \quad (1)$$

here:

$Q_{\text{const.}}$ – amount of heat lost by the building's external barrier structures, W;

Q_{vent} – amount of heat lost by ventilation, W;

$Q_{\text{ht.rel.}}$ - calculated heat release, W.

The energy efficiency of building 78 on Fergana Street has been calculated. The thermal resistance of external walls ($R_0=0.89 \text{ m}^2 \cdot \text{°C/W}$), windows ($R_0=0.22 \text{ m}^2 \cdot \text{°C/W}$), doors ($R_0=0.16 \text{ m}^2 \cdot \text{°C/W}$), roofs ($R_0=1.56 \text{ m}^2 \cdot \text{°C/W}$) and basement floors ($R_0=0.60 \text{ m}^2 \cdot \text{°C/W}$) exceeded the normative values (2.2; 0.53; 0.59; 3.0; 1.96 $\text{m}^2 \cdot \text{°C/W}$). Total heat losses amounted to 164 791 W, specific heat consumption - 83.7 W/m^2 , which is 46.8% higher than the standard indicator (57 W/m^2). The building's energy efficiency corresponds to category "G" which indicates the need for major repairs aimed at increasing energy efficiency.

In the study, it was substantiated that the joint implementation of technical inspection and energy efficiency assessment of buildings reduces labor and time resources by an average of 20% due to the generalization of instrumental and technical research in the collection of building data, the development of drawings.

This chapter laid the foundation for the development of practical recommendations for experimental studies of the energy efficiency of MABs and their modernization.

In the fourth chapter of the dissertation, entitled **“Recommendations for improving the energy efficiency of apartment buildings”** an algorithm for assessing the energy efficiency of apartment buildings was developed, taking into account the climatic features of the region, and based on this algorithm, a calculation platform energiyasamaradorbino.uz was created. The platform is an interactive web-software adapted to urban planning norms and rules for various climatic zones of Uzbekistan, calculating the energy consumption of existing and modernized buildings and determining the potential for savings. As a result, it is planned to accelerate and simplify the decision-making process for engineers and designers by automating complex heat engineering calculations.

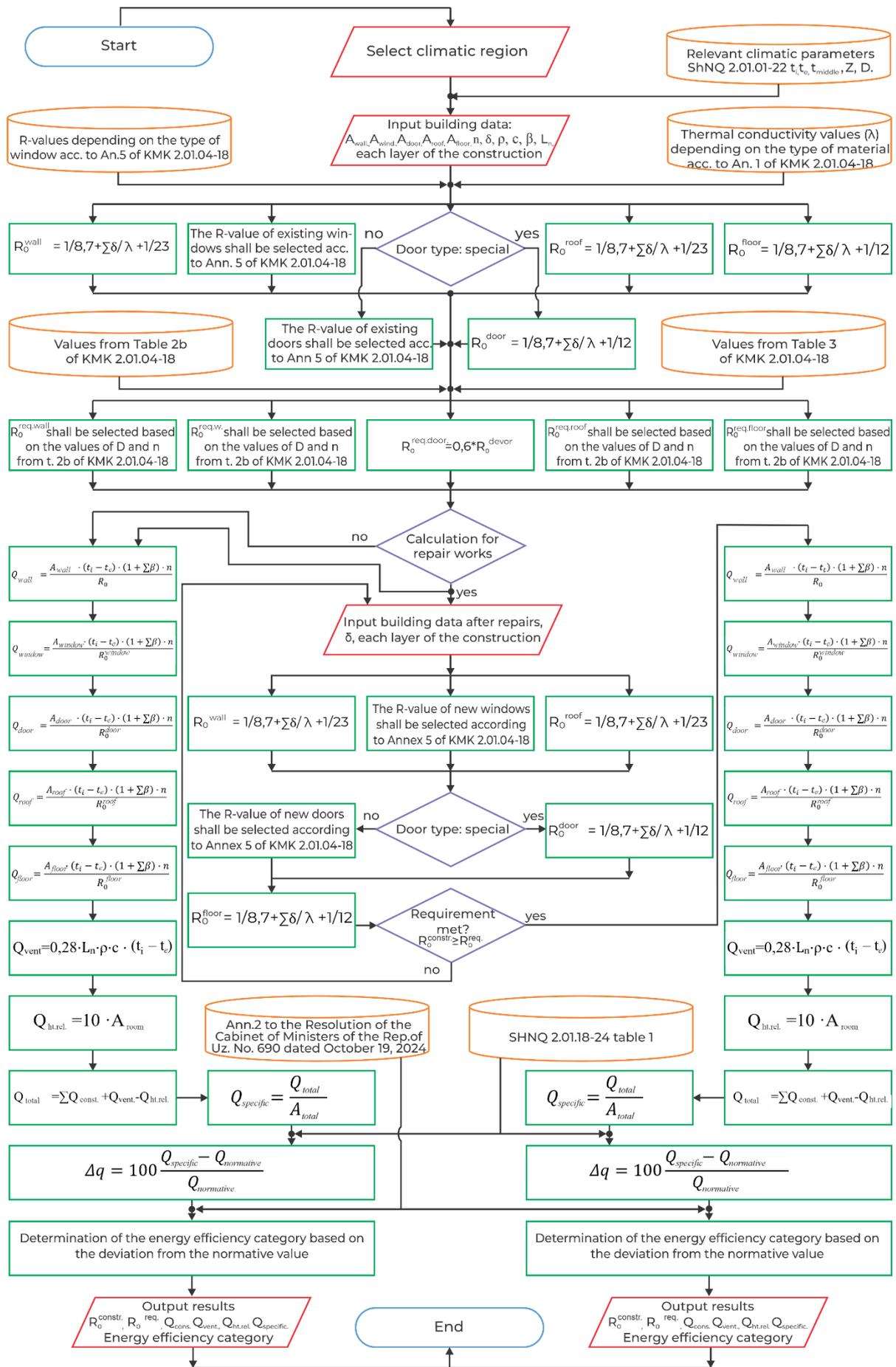


Figure 8. Block diagram of the algorithm for the operation of a platform for assessing the energy efficiency of apartment buildings.

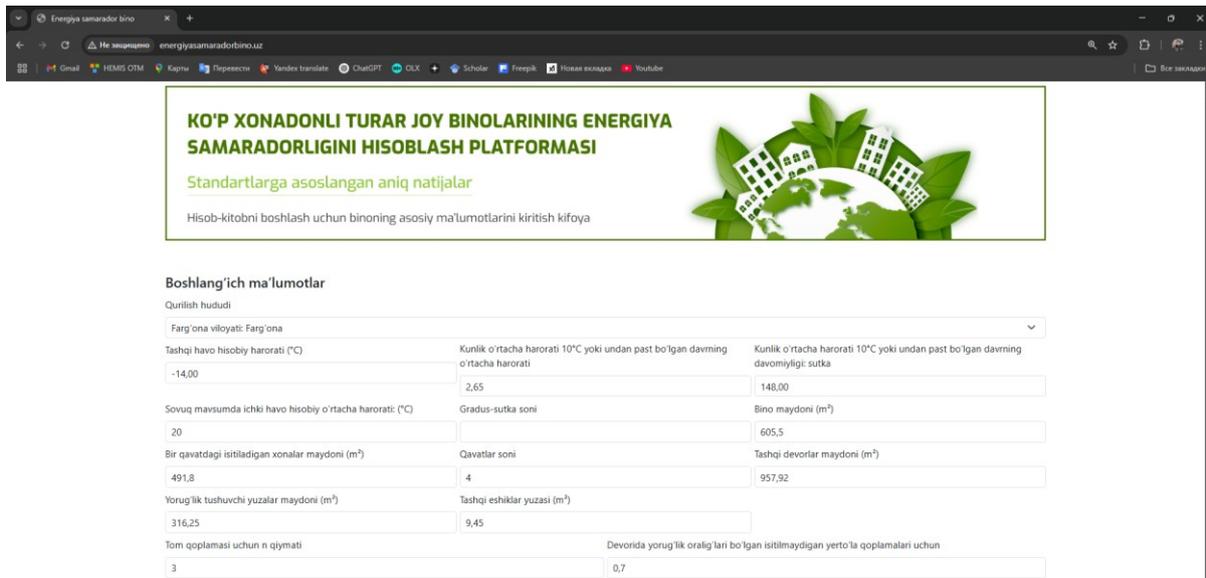


Figure 9. Platform homepage

By entering the main building parameters into the platform, it is possible to automatically calculate the heat conductivity resistance of building structures, heat loss, and the energy class of the building.

Table 2
Difference of R_0 values of the structures of the research object with the required level.

№	Name of structures	$R_0, m^2 \times ^\circ C/W$	$R_0^{req.}, m^2 \times ^\circ C/W$	Deviation from standard value, $m^2 \times ^\circ C/W$
1	Exterior wall	0,89	2,20	-1,31
2	Window	0,22	0,53	-0,31
3	Door	0,16	0,59	-0,43
4	Roofing	1,56	3,00	-1,44
5	Floor	0,60	1,96	-1,36

To compensate for the resulting negative difference, it is necessary to carry out insulation work on the building.

To increase the thermal efficiency of the structures, an analysis of 4 facade insulation systems was carried out. 1-wet facade system, 2-facade system with ventilation, and the proposed 3th thermal panel and 4th thermal panel systems with ventilation, the schemes of systems 3 and 4 are described in detail below.

A scheme of thermal insulation systems for the roof and floor parts of the building was proposed. Accordingly, extruded polystyrene foam (XPS panel) was chosen as the main thermal insulation material. The reason is that this material is considered lightweight and has low thermal conductivity, and is an effective thermal insulation material. When insulating the floor part, it is proposed to insulate the basement part of the building from the lower part of the 1st floor covering, since this provides for the replacement of floor coverings in the apartments and the achievement of protection from changes in room height.

It is proposed to replace external windows with energy-efficient 2-chamber window frames with selective internal heat-insulating coating, and external doors with an energy-efficient layer of mineral wool based on basalt in the inner part.

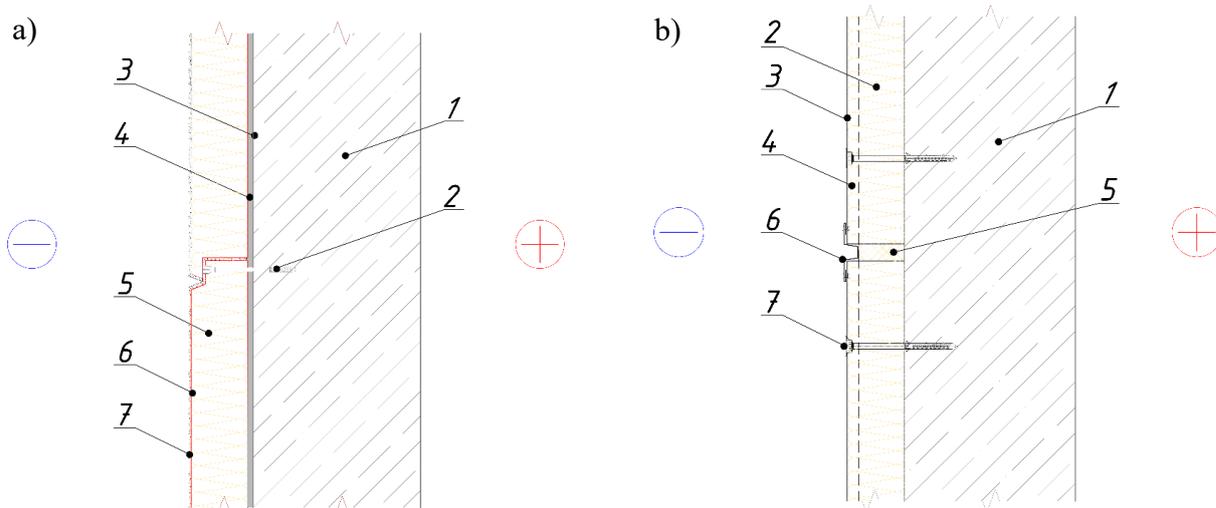


Figure 10. External wall thermal insulation systems. a) thermal panel system; 1 - wall; 2 - plate fastening double (8 for 1 m²); 3 - primer; 4-polymer-cement glue (10mm); 5-mineral wool board (100mm); 6-glued basalt mesh (8x8 mm); 7-external decorative coating based on quartz sand and polymer adhesive (5 mm); b) thermal panel system with ventilation; 1 - load-bearing wall; 2-basalt-based mineral wool board (100mm); 3 - metal sheet covering; 4 - airflow cavity; 5-intermediate layer based on mineral wool; 6-metal sheet covering with holes for closing the panel seam and organizing airflow; Set of fastening duplicates for fastening panel No. 7 (4 for 1m²).

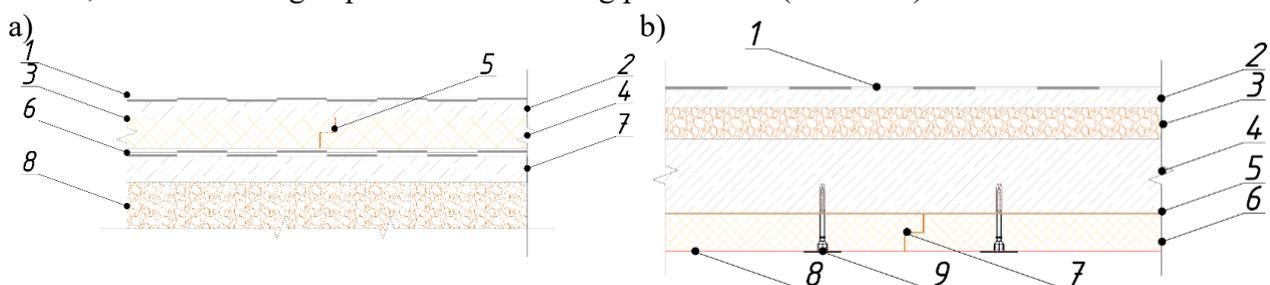


Figure 11. Roof and floor insulation schemes. a) Roof insulation layers. 1-two-layer waterproofing coating (Technoelast EPP+Technoelast K TKP); 2-cement-sand mixture (30 mm); 3-moisture-protective polyethylene coating; 4-XPS panel (60 mm); 5-adhesive using assembly foam adhesive; 6-existing waterproofing; 7-existing concrete layer, 8-existing expanded clay. b) scheme for installing floor insulation. 1-existing linoleum; 2-cement-sand mixture (30 mm); 3-expanded clay; 4-existing floor slab; 5-adhesive using assembly foam adhesive; 6-XPS panel 60-80 mm (Penoplex); 7-adhesive using assembly foam adhesive; 8-moisture-protective film; 9 - Fastening doublet (8 per 1m²).

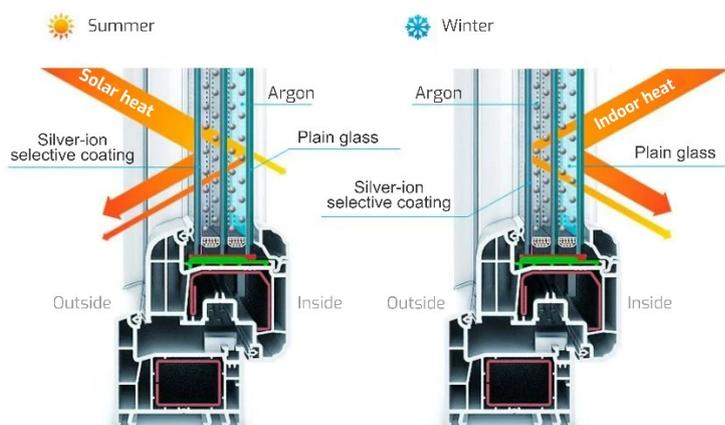


Figure 12. Performance of two-chamber energy-efficient window frames in summer and



Figure 13. Basalt inner layer of a modern entrance hall door.

In the above recommended methods, the external building structures achieve thermal resistance R_0 , allowing them to reach the second-level thermal protection.

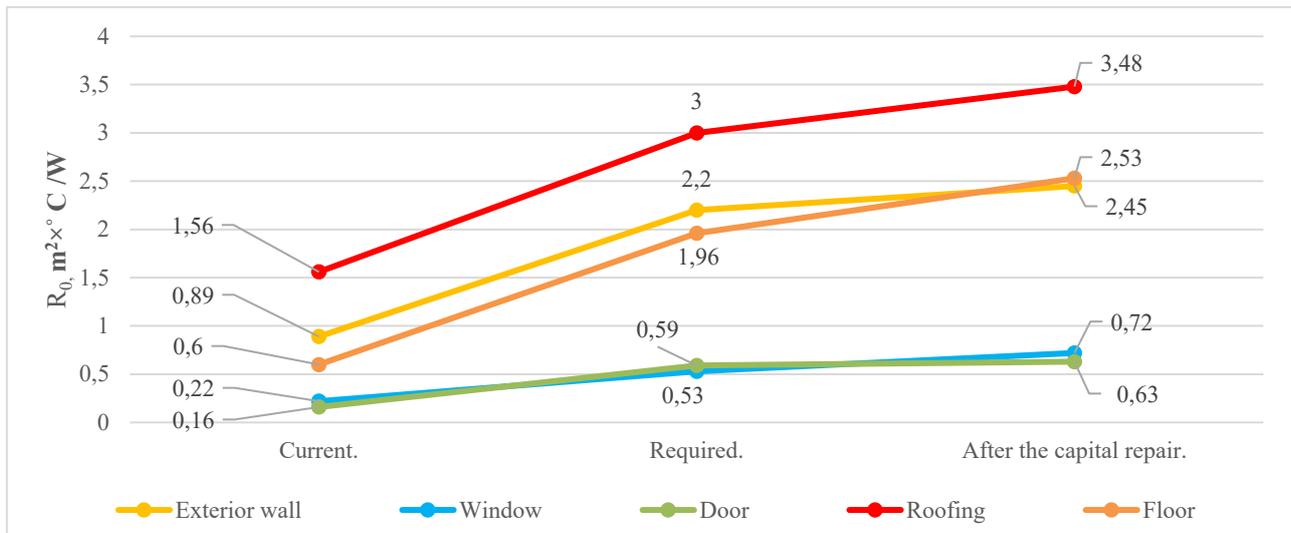


Figure 14. Diagram of changes in the value of structures R_0 after major repairs.

Based on the costs of capital repairs, the "Optimal" and "Economic" methods of capital repairs of buildings are proposed, which include measures for thermal insulation of all the above-mentioned structures and do not provide for the replacement of external windows.

Table 3

Total heat loss and release

№	Status	Heat loss from structures, W.	Heat loss from ventilation, W.	Calculated heat release, W.	Total, W.	Specific heat consumption W/m²	Energy class
1	Current	131 866	46 495	13 570	164 791	83,70	G
2	Optimal	42 153			75 078	38,16	B
3	Economic	78 557			111 482	56,67	D

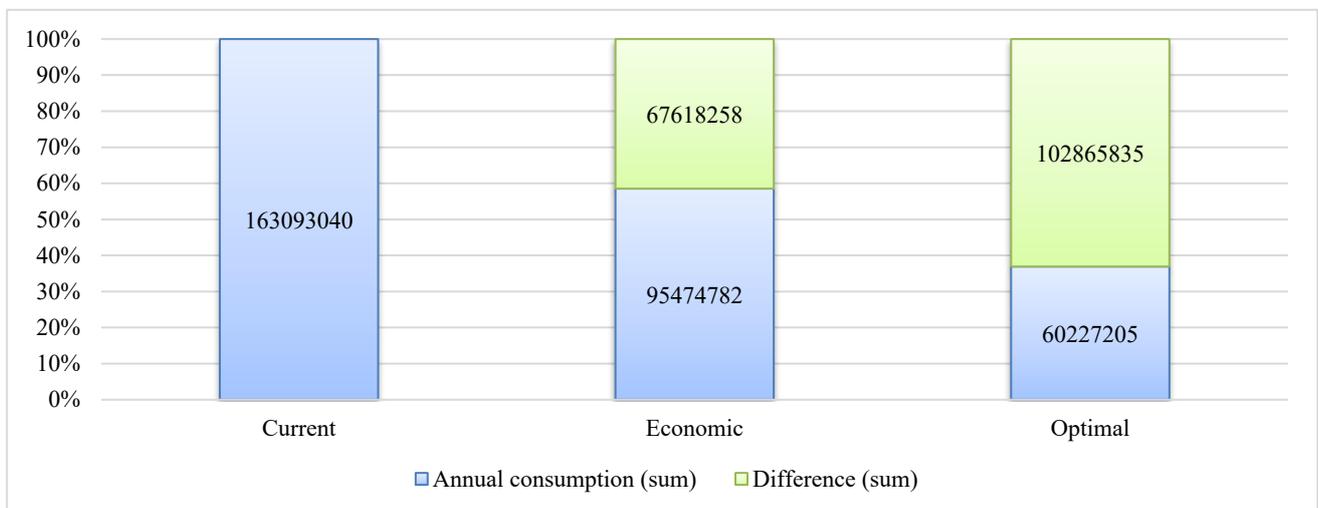


Figure 15. Difference between expected energy consumption prices for repairs in the "Optimal" and "Economic" methods and annual energy costs in the current situation.

Table 4

Comparison of total costs

№	Type of exterior wall insulation	Total capital repair costs, sum	
		Economic	Optimal
1	Wet facade system	398 359 208	975 054 108
2	Ventilation facade system	555 531 226	1 132 226 126
3	Thermopanel	519 763 512	1 096 458 412
4	Ventilation thermopanel	516 853 344	1 093 548 244

An economic analysis of the difference between the costs of heating and cooling in the current state of the building and changes in energy efficiency was carried out. Due to the reduction in annual costs, it is substantiated that with the "Optimal" method of building repair, 975.05 million soums of repair costs will be recovered in 9.5 years, and with the "Economic" method of capital repair, 398.36 million soums will be recovered in 5.9 years.

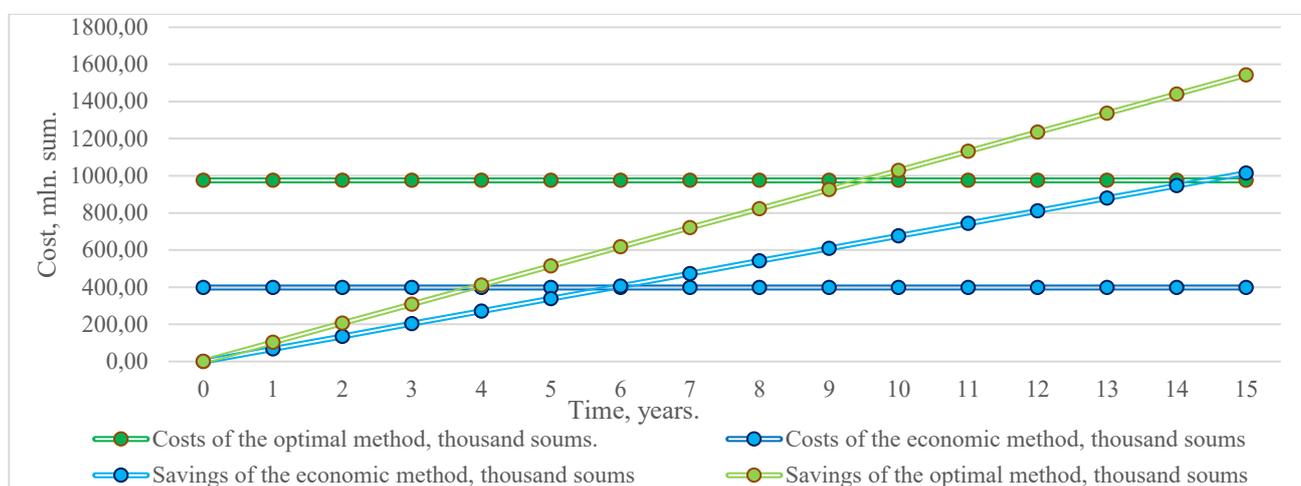


Figure 16. Diagram of the payback period of capital repair costs.

It was calculated that the amount of CO₂ released into the atmosphere decreases due to a decrease in energy consumption.

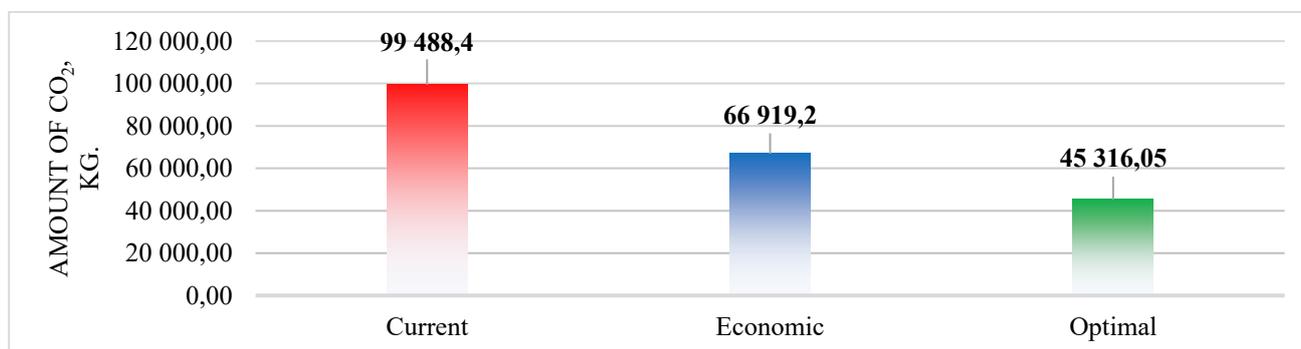


Fig. 17. Difference between the current condition of the building and CO₂ emissions during capital repairs

Capital repairs, along with restoring the condition of buildings, increase energy efficiency, improve living conditions and infrastructure, and reduce the environmental impact.

CONCLUSIONS

Based on the results of the experimental and theoretical research conducted for the doctoral dissertation (PhD) on the topic "Issues of assessing and improving energy efficiency of operating apartment buildings" the following general conclusions were made:

1. Most of the MABs in the city of Fergana were built in the 1960s-1990s, and their structural and engineering systems were found to be significantly outdated. In the Kirguli district, the main part of the houses consists of 4-story panel houses of series 1-464a, and it turned out that the population widely uses inefficient and dangerous heating devices, such as kitchen gas stoves and electric heaters.

2. Regional factors influencing the energy efficiency of apartment buildings were systematically analyzed by dividing them into groups A - natural and technogenic factors and B - subjective factors.

3. Technical inspection of a 4-story panel building and a 2-story brick building in the Kirguli district, as well as 3D modeling in the LIRA-SAPR 10.12 program, showed that the panel building is resistant to seismic loads, and the brick building is unstable due to high stresses in its structures, therefore large-panel buildings need major repairs, and brick buildings need renovation.

4. In the 4-story panel (1-464a) and 2-story brick (1-204) buildings of the city of Fergana, high heat losses were determined using a thermal imager (UNI-T UTi260B) in panel joints, window-door perimeters, roof and floor zones.

5. It was theoretically determined that by conducting joint instrumental and technical inspections of the technical condition of apartment buildings and assessing energy efficiency, labor and time resources will be reduced by 20%.

6. The thermal resistance of external structures in a panel building (R_0) is below standard requirements (exterior wall: -59.55%, window: -58.49%, door: -72.88%). Total heat loss is 164 791 W, specific consumption is 83.7 W/m² (norm: 57 W/m²), which indicates that the building belongs to the energy class "G."

7. The web platform energiyasamaradorbino.uz (MVC, PHP, MySQL), adapted to the climatic zones of Uzbekistan, simplified the formation of energy passports and the economic justification of modernization measures, reducing the calculation time from 2-3 hours to 10-12 minutes.

8. It has been proven that the use of mineral wool based on basalt (100 mm) and extruded polystyrene foam (XPS, 60 mm) reduces heat losses by 32-54%, ensures standard P_0 values, and increases energy efficiency by 25-40% and the potential for changing the energy class of the building to category B.

9. The economic efficiency of ventilated facade panels in the insulation of external walls of apartment buildings has been proven by 1.1 times due to a reduction in time and labor costs during installation compared to ventilated facades.

10. The "Optimal" repair (975 million soums) reduces energy consumption from 298 424 kWh to 137 635 kWh, and the "Economic" method (398 million soums) - to 202 066 kWh. It is substantiated that the investment will be recovered in 5.9-9.5 years, and the annual CO₂ emission will decrease to 32.5-54.2 (32.7%-54.5%) tons.

**НАУЧНЫЙ СОВЕТ PhD.03/07.06.2024. Т.106.06 ПО ПРИСУЖДЕНИЮ
УЧЕНЫХ СТЕПЕНЕЙ ПРИ ФЕРГАНСКОМ ГОСУДАРСТВЕННОМ
ТЕХНИЧЕСКОМ УНИВЕРСИТЕТЕ**

**ФЕРГАНСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ
УНИВЕРСИТЕТ**

На правах рукописи
УДК 699.86

ХАЛИМОВ АББОСБЕК ОЙБЕК УГЛИ

**ВОПРОСЫ ОЦЕНКИ И ПОВЫШЕНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ
ЭКСПЛУАТИРУЕМЫХ МНОГОКВАРТИРНЫХ ДОМОВ**

05.09.01–Строительные конструкции, здания и сооружения

АВТОРЕФЕРАТ

диссертации доктора философии (PhD) по техническим наукам

Фергана–2025

Тема диссертации на соискание учёной степени доктора философии (PhD) зарегистрирована в Высшей аттестационной комиссии при Министерстве высшего образования, науки и инноваций Республики Узбекистан под номером B2025.3.PhD/T5810

Диссертация выполнена в Ферганском государственном техническом университете.

Автореферат диссертации на трех языках (узбекский, русский, английский (резюме)) размещен на веб-странице (www.fstu.uz) и на Информационно-образовательном портале «ZiyoNet» (www.ZiyoNet.uz)

Научный руководитель:

Хотамов Асадулла Тоштемирович
доктор технических наук, профессор

Официальные оппоненты:

Ювмитов Анвар Сайфуллаевич
доктор технических наук, старший научный сотрудник

Норов Нусиратжон Нуралиевич

доктор философии технических наук, доцент

Ведущая организация:

**Наманганский государственный
технический университет**

Защита диссертации состоится «31» октября 2025 года в 14³⁰ часов на заседании Научного совета PhD.03/07.06.2024.T.106.06 при Ферганском государственном техническом университете по адресу: Ферганская область, город Фергана, ул. Ферганская, дом 86. Тел./факс: (99873) 241-12-06/241-12-06, e-mail: www.fstu.uz

С диссертацией можно ознакомиться в Информационно-ресурсном центре Ферганского государственного технического университета (зарегистрирован за № 296). (Адрес: г. Фергана, ул. Ферганская, 86. Тел./факс (99869) 234-15-23, e-mail: info@fstu.uz).

Автореферат диссертации разослан “17” октября 2025 года.

(протокол рассылки № 1/2025-7 от “15” октября 2025 г.).

С.Ф.Эргашев

Председатель научного совета
по присуждению ученых степеней,
доктор технических наук, профессор

Ш.А.Умаров

Ученый секретарь научного совета
по присуждению ученых степеней,
доктор философии технических наук, доцент

Х.А.Акрамов

Председатель научного семинара при научном
совете по присуждению ученых степеней,
доктор технических наук, профессор

ВВЕДЕНИЕ (аннотация диссертации доктора философии (PhD))

Актуальность и востребованность темы диссертации. В связи со стабильным ростом мирового спроса на энергетические ресурсы, в настоящее время особое внимание уделяется вопросам повышения энергоэффективности при проектировании современных зданий и капитальном ремонте существующих объектов, а также рациональному использованию энергии, расходуемой на отопление. На сегодняшний день, по состоянию на 2024 год, мировой спрос на энергию увеличился на 2,2% и составил 640×10^{18} джоулей (640 эксаджоулей). Потребление электроэнергии особенно значительно возросло — на 4,3%, превысив темпы роста мирового валового внутреннего продукта (3,2%). В 2024 году потребление электроэнергии в зданиях достигло рекордного уровня, составив 60% от общего мирового объема, что связано с увеличением потребностей в отоплении и охлаждении. В этом контексте разработка практических решений по повышению энергоэффективности зданий, рациональному управлению энергопотреблением и энергосбережению приобретает особую актуальность.

В мировой практике проводятся широкомасштабные научно-исследовательские работы, направленные на обеспечение энергоэффективности зданий. В этих исследованиях приоритетное значение имеет уменьшение количества энергии, теряемой через наружные ограждающие конструкции зданий, а также совершенствование конструкций. В развитых странах, в частности в США, Канаде, Германии, Финляндии, России, Китае и Японии, накоплен большой опыт в проектировании энергосберегающих зданий и повышении энергоэффективности существующих сооружений. С целью дальнейшего улучшения энергоэффективности зданий разрабатываются и внедряются новые конструктивные решения, в том числе совершенствуются методы оценки энергоэффективности зданий и способы снижения количества тепловых потерь через наружные ограждающие конструкции, что является одной из актуальных задач.

В нашей Республике в последние годы осуществляются широкомасштабные реформы, направленные на разработку и практическое применение новых технологий, способствующих повышению энергоэффективности зданий. Определены задачи по проведению «Научных исследований в области зеленых технологий»¹, «Внедрению сертификата “Зеленое здание” для новых строительных объектов и жилых домов исходя из их энергоэффективности»². В этом направлении, в частности, важное научно-практическое значение имеют вопросы дальнейшего совершенствования методов определения и оценки уровня энергоэффективности многоквартирных домов, а также повышения тепловой защиты зданий за счет широкого внедрения современных теплоизоляционных строительных материалов и инновационных

¹ Постановление Президента Республики Узбекистан от 11 марта 2025 года № ПП-100 «О мерах по кардинальному реформированию сферы обеспечения тепловой энергией жилых домов, зданий и сооружений, а также повышению энергоэффективности зданий».

² Указ Президента Республики Узбекистан от 30 января 2025 года № УП-16 «О Государственной программе по реализации Стратегии «Узбекистан — 2030» в «Год охраны окружающей среды и «зеленой экономики»».

конструктивных решений.

Объявление 2025 года в Республике Узбекистан Годом охраны окружающей среды и «зелёной» экономики, а также Указы Президента Республики Узбекистан от 28 января 2022 года № УП-60 «О Стратегии развития Нового Узбекистана на 2022 — 2026 годы», от 11 сентября 2023 года № УП-158 «О Стратегии “Узбекистан – 2030”», Постановление Президента от 16 февраля 2023 года № ПП-57 «О мерах по ускорению внедрения возобновляемых источников энергии и энергосберегающих технологий в 2023 году», и Постановление Президента от 11 марта 2025 года № ПК-100 «О мерах по кардинальному реформированию сферы обеспечения тепловой энергией жилых домов, зданий и сооружений, а также повышению энергоэффективности зданий» — все эти документы определяют задачи, реализация которых способствует достижению целей, предусмотренных нормативно-правовыми актами в данной сфере. Настоящее диссертационное исследование в определённой степени вносит свой вклад в выполнение указанных задач и достижение обозначенных целей.

Соответствие исследования приоритетным направлениям развития науки и технологий Республики Узбекистан. Диссертационная работа выполнена в соответствии с приоритетным направлением II «Энергетика, энерго и ресурсосбережение» развития науки и технологий Республики Узбекистан.

Степень изученности проблемы. Проблема энергоэффективности является актуальной во всём мире, в связи с чем в данной области ведутся постоянные научные исследования. Вопросы, связанные с этой темой, изучались зарубежными и учёными стран СНГ, такими как: Р.М.Алоян, С.В.Федосов, Л.А.Опарина, Н.В.Пилипенко, Ю.Г.Киселева, М.С.Мягкова, А.Лари, В.М.Фокин, А.Галата, Х.М.Андухар, С.Г.Мелгар, А.Е.Кирюдчева, Д.О.Советников, П.В.Монастрев, А.М.Макаров, С.В.Корниенко, Ч.Костантино, А.Ч.Бенедетти, Р.Гулли, В.Милич, П.Родин, М.Упис, И.Амолина, И.Гейпеле, Н.Зелтиньш, А.Папоян, Ч.Жан, С.Хан, Г.Ли, Чжан Х. и другими исследователями.

В Республике Узбекистан исследования в области энергоэффективности гражданских зданий проводились М.М.Зохиловым, Г.Ш.Шукуровым, С.М.Махмудовым, Э.С.Тулаковым — по вопросам повышения энергоэффективности зданий; Р.Й.Маракаевым, Н.Н.Норовым — по вопросам проектирования энергоэффективных зданий в условиях Узбекистана; Ж.В.Эшмуродовым, К.Эдмуродовым, С.А.Ходжаевым, Р.Р.Кадыровым, Э.В.Шипачёвой, М.Набиевым — по проектированию энергоэффективных зданий в условиях сухого и жаркого климата; М.А.Короли, М.Б.Худяровым — по направлениям энергетического аудита зданий. Влияние природных, техногенных и антропогенных факторов на энергоэффективность зданий в жилых массивах, а также вопросы оптимального размещения зданий относительно горизонта изучались И.С.Шукуровым, А.Т.Хотамовым, Х.Ф.Аллабергановым и Б.Э.Дусатовым.

На основании аналитических показателей установлено, что проблема оценки энергоэффективности многоквартирных жилых домов остаётся

недостаточно изученной. Возникает необходимость разработки методов оценки энергоэффективности многоквартирных зданий с учётом территориальных и климатических условий Республики Узбекистан.

Связь диссертационного исследования с планами научно-исследовательских работ высшего учебного заведения, в котором выполнена диссертация. Диссертационное исследование выполнено в соответствии с планом научно-исследовательских работ Ферганского государственного технического университета в рамках проекта по теме «Программа устойчивости и промышленных инноваций» (2024–2025 годы).

Цель исследования заключается в оценке энергоэффективности существующих многоквартирных жилых домов и определении способов снижения потерь тепла через наружные ограждающие конструкции.

Задачи исследования:

провести анализ научной литературы и практических исследований, посвящённых оценке и повышению энергоэффективности зданий;

осуществить мониторинг существующих многоквартирных жилых домов, расположенных в махалле Киргули города Ферганы, и выявить основные проблемы, связанные с потерями энергии;

определить теоретико-методические основы оценки энергоэффективности многоквартирных жилых домов;

разработать электронную платформу для автоматизации расчётов по совершенствованию методов оценки энергоэффективности многоквартирных домов;

разработать конструктивные и технические решения, направленные на снижение теплопотерь через наружные ограждающие конструкции многоквартирных домов;

определить практическую ценность предлагаемых решений путём оценки их экономической эффективности.

В качестве **объекта исследования** выбраны эксплуатируемые многоквартирные жилые дома, расположенные в махалле Киргули города Ферганы.

Предметом исследования являются энергоэффективность эксплуатируемых многоквартирных жилых домов, в частности методические и практические аспекты оценки и повышения уровня их тепловой защиты.

Методы исследования. В исследовании использовались методы статистического анализа, оценки, натурных обследований реальных объектов и сравнительного анализа.

Научная новизна исследования заключается в следующем:

усовершенствована методика оценки энергоэффективности многоквартирных жилых домов за счёт разработки алгоритма, учитывающего изменения сопротивления теплопередаче конструкций зданий после капитального ремонта;

разработана онлайн-платформа для расчёта, позволяющая в короткие сроки комплексно оценить энергоэффективность многоквартирных домов и повысить их тепловой энергетический класс на основе изменения удельного

теплопотребления здания;

установлено, что при интегрированном подходе к проведению инструментально-технических обследований технического состояния и оценке энергоэффективности многоквартирных домов трудовые и временные затраты сокращаются на 20%;

доказано, что при использовании фасадных панелей в качестве теплоизоляции наружных стен многоквартирных домов достигается экономическая эффективность в 1,1 раза за счёт упрощённой конструкции панелей и механизации монтажного процесса по сравнению с вентилируемыми фасадами.

Практические результаты исследования заключаются в следующем:

в процессе оценки энергоэффективности многоквартирных домов обеспечена точность и достоверность оценки за счёт учёта конструктивных и технологических изменений после капитального ремонта, а также усовершенствован методический механизм оценки;

разработана автоматизированная онлайн-платформа energiayasamardor-bino.uz, позволяющая в короткие сроки выполнять расчёт энергоэффективности зданий и определять их тепловой энергетический класс;

объединение процессов инструментально-технического обследования технического состояния и оценки энергоэффективности многоквартирных домов позволило обеспечить рациональное использование трудовых и временных ресурсов;

детально изучены технологические процессы использования вентилируемых фасадных панелей при изоляции наружных стен, установлено, что выполнение монтажа «сухим методом» повышает строительную эффективность, а также обоснованы их технологические преимущества.

Достоверность результатов исследования. Теоретические расчёты, использованные в ходе исследования, основаны на действующих строительных нормах и правилах. Комплексный анализ факторов, влияющих на теплопотери, и их научно обоснованная систематизация обеспечили достоверность полученных результатов. Кроме того, результаты, полученные с помощью разработанной онлайн-платформы, функционирующей на основе расчётных алгоритмов, подтверждаются их соответствием существующим практическим данным.

Научная и практическая значимость результатов исследования. Научная значимость результатов исследования заключается в разработке адаптированного к региональным условиям онлайн-алгоритма и платформы для оценки эффективности тепловой защиты эксплуатируемых многоквартирных жилых домов, а также во внесённом в теорию оценки энергоэффективности вкладе через научно обоснованный анализ конструктивных решений по уровню их тепловой защиты.

Практическая значимость результатов исследования заключается в разработке и предложении технически и экономически обоснованных конструктивных решений, способствующих повышению энергоэффективности существующего жилищного фонда; создании возможности оценки теплопотерь

зданий посредством онлайн-платформы energiayasamardorbino.uz; а также в возможности предварительной оценки эффективности ремонтных мероприятий на основе расчётных данных.

Внедрение результатов исследования. На основе научных результатов исследования по теме «Вопросы оценки и повышения энергоэффективности эксплуатируемых многоквартирных домов»:

Методика оценки энергоэффективности многоквартирных домов была усовершенствована за счёт разработки алгоритма, учитывающего изменения сопротивления теплопередаче конструкций после капитального ремонта. Разработана онлайн-платформа, обеспечивающая комплексную оценку энергоэффективности здания в короткие сроки и определение его теплового энергетического класса на основе изменения удельного теплотребления. Предложения по применению данной методики использованы проектной организацией ООО “Fargonafuqaroloyiha” при разработке проекта 7-этажного жилого дома по улице Хирмонтепа, Сохского района (справка Министерства строительства и жилищно-коммунального хозяйства Республики Узбекистан №34–06/10251 от 10 сентября 2025 года). В результате достигнута экономия времени при теплотехнических расчётах до 25% по сравнению с традиционными методами.

Предложения по совместному проведению инструментально-технического обследования технического состояния многоквартирных домов и оценки их энергоэффективности на основе интегрированного подхода, а также по применению упрощённых фасадных панелей в качестве теплоизоляции наружных стен, что обеспечивает снижение трудозатрат и времени монтажа по сравнению с вентилируемыми фасадами и увеличение экономической эффективности в 1,1 раза, были использованы ООО “Constraction Test Laboratory” при строительстве 5-этажного жилого дома по улице Б. Маргилони, г. Маргилан (справка Министерства строительства и жилищно-коммунального хозяйства Республики Узбекистан №34–06/10251 от 10 сентября 2025 года). В результате применения предложенных методов достигнута экономическая эффективность до 10%.

Апробация результатов исследования. Результаты диссертационной работы были обсуждены на 8 международных и 2 республиканских научно-практических конференциях.

Публикации результатов исследования. По теме диссертации опубликовано всего 19 научных работ, из них 6 статей — в изданиях, рекомендованных Высшей аттестационной комиссией Республики Узбекистан для публикации основных научных результатов диссертаций на соискание учёной степени доктора философии (PhD), в том числе 5 статей — в республиканских и 1 статья — в зарубежном научном журнале.

Структура и объём диссертации. Диссертация состоит из введения, четырёх глав, выводов, списка использованных источников и приложений. Объём диссертации составляет 120 страниц.

E'LON QILINGAN ISHLAR RO'YHATI
LIST OF PUBLISHED WORKS
СПИСОК ОПУБЛИКОВАННЫХ РАБОТ

I bo'lim (part I, I часть)

1. Xalimov A.O. “Binolar energiyasamaradorligiga ta'sir etuvchi omillarning fuqaro binolari qurilishidagi tutgan o'rni va qayta tiklanuvchi energiya manbaalarining ahamiyati”// “Farg‘ona politexnika instituti ilmiy-texnika jurnali” 2023, T.27. Maxsus son № 7, 160-163 b, ISSN 2181-7200 (05.00.00 №20)
2. Xalimov A.O. “Processes of heat transfer from building structures of buildings” // Spectrum Journal of Innovation, Reforms and Development. 2023, Volume 22, 137-142 b. ISSN (E): 2751-1731. Website: www.sjird.journalspark.org (2) Journal Impact Factor
3. Xalimov A.O. “Energiyasamarador kam qavatli turar joy binolarining konstruktiv yechimlari tahlili” //“Farg‘ona politexnika instituti ilmiy-texnika jurnali” 2024, T.27. Maxsus son № 3, 67-70 b, ISSN 2181-7200 (05.00.00 №20)
4. Xotamov A.T., Xalimov A.O. “Farg‘ona shahrida uy-joy qurilishining rivojlanishi” //“Farg‘ona politexnika instituti ilmiy-texnika jurnali” 2024, T.27. Maxsus son № 31, 58-63 b, ISSN 2181-7200 (05.00.00 №20)
5. Xotamov A.T., Dusatov B.E., Xalimov A.O. “Shahar turar joy hududlaridagi binolarning energiya tejamliligini oshirish masalalari”//“Farg‘ona politexnika instituti ilmiy-texnika jurnali” 2025, T.29. Maxsus son № 2, 57-62 b, ISSN 2181-7200 (05.00.00 №20)
6. Xotamov A.T., Xalimov A.O. “Ko‘p kvartirali uylarni kapital ta'mirlash asosida energiya samaradorlik darajasini optimallashtirish imkoniyatlari”// Toshkent arxitektura-qurilish universiteti “Arxitektura, qurilish va dizayn” ilmiy-amaliy jurnali, vol. 20, Issue 2, Iyun 2025, 709-718 b, ISSN 2010-7064 (05.00.00 №4)
7. Xotamov A., Nabiyev M., Salimov O., Xalimov A., Akhmedov T., Nasriddinov X., Abdurakhmonov U., Raximov R., Abobakirov A. “Effect of external air temperature on buildings and structures and monuments” In E3S Web of Conferences (Vol. 474, p. 03011). X International Annual Conference “Industrial Technologies and Engineering” (ICITE 2023)

II bo'lim (part II; II часть)

8. Xotamov A.T., Xalimov A.O. “Kam qavatli turar joy binolarining konstruktiv yechimlari taxlili”//“Shaharlarni rivojlantirish tendensiyalari va istiqbollari” xalqaro ilmiy-amaliy anjuman. 2023, 271–276. Toshkent.
9. Xalimov A.O. “Energiyasamarador tom konstruksiyalarining zamonaviy yechimlari.”// “Iqtidorli talabalar, magistrantlar, doktorantlar va mustaqil izlanuvchilar” respublika ilmiy-amaliy anjumani. 2023, 23-24 iyun. Farg‘ona.

10. Xalimov A.O. “Rivojlangan mamlakatlarda binolar energiya samaradorligini tartibga soluvchi me’yorlar tahlili”// “Qurilishda energiya samaradorlikni oshirishning istiqboldagi vazifalari” respublika anjumani. 2024, 24-noyabr. Toshkent.
11. Xalimov A.O. “Farg‘ona shahri, Qirguli mavzesidagi mavjud ko‘p kvartirali uylarning hozirgi holati” “Iqtidorli talabalar, magistrantlar, doktorantlar va mustaqil izlanuvchilar” respublika ilmiy-amaliy anjumani. 2024, 25-26 iyun. 180-182 b. Farg‘ona.
12. Xotamov A.T., Xalimov A.O. “O‘zbekistonda bino va inshootlarning energiya samaradorligi toifasini aniqlash”// “Energiya va resurs tejamkor binolar qurilishida, zamonaviy qurilish materiallari va texnologiyalari” mavzusidagi Xalqaro ilmiy va ilmiy-texnik konferensiya. 2024, 19-20 dekabr. 107-109 b. Farg‘ona.
13. Xalimov A.O. “O‘zbekistonda bino va inshootlarni energiya auditidan o‘tkazish tartibi”// “Energiya va resurs tejamkor binolar qurilishida, zamonaviy qurilish materiallari va texnologiyalari” mavzusidagi Xalqaro ilmiy va ilmiy-texnik konferensiya. 2024, 19-20 dekabr. 109-112 b. Farg‘ona.
14. Xalimov A.O. “Energy efficiency issues of multi-apartment buildings”// “Arxitektura, qurilish va muhandislik sohalarida zamonaviy qurilish materiallari va texnologiyalari” mavzusida xalqaro ilmiy va ilmiy-texnik konferensiya. 2025, 16-17 may, 141-146 b. Namangan.
15. Xalimov A.O. “Turar joy binolari konstruksiyalarining me’yoriy issiqlik uzatishga qarshiligini hisoblash” // “Farg‘ona viloyatida zilzilabardosh bino va inshootlar qurilishidagi dolzarb muammolar” xalqaro ilmiy-amaliy konferensiya. 2025, 16-17 may, 177-180 b, Farg‘ona.
16. Xalimov A.O. “Farg‘ona shahar, Qirguli mavzesidagi ekspluatatsiyadagi ko‘p kvartirali uylar va ularning tashqi devorlaridan issiqlik yo‘qotilishi tahlili” // “Zilzilabardoshlik sohasida salohiyatni oshirish” xalqaro ilmiy-amaliy anjumani. 2025, 10-13-mart, 441-448 b. Toshkent.
17. Xalimov A.O. “Turar joy binolarining oshxona va yashash xonalarining me'yoriy deraza yuzalarini hisoblash” //05.09.2023 yil №DGU 27234 Guvohnoma O‘z.Res. Adliya vazirligi huzuridagi Intellektual mulk agentligi tomonidan berilgan.
18. Xalimov A.O. “Qirguli Kku” – “Qirguli mavzesi ko‘p kvartirali uylari ma’lumotlar bazasi” // 29.04.2024 yil №DGU 27234 Guvohnoma O‘zRes. Adliya vazirligi huzuridagi Intellektual mulk agentligi tomonidan berilgan.
19. Xotamov A.T., Xalimov A.O. “Ko‘p kvartirali uylarning energiya samaradorligini baholash platformasi”// 08.09.2025 yil №DGU 54471 Guvohnoma O‘zRes. Adliya vazirligi huzuridagi Intellektual mulk agentligi tomonidan berilgan.

Avtoreferatning o‘zbek, rus va ingliz tillaridagi nusxalari
Farg‘ona davlat texnika universitetining “Ilmiy texnika” jurnali
tahririyatida tahrirdan o‘tkazildi.
(13.10.2025 yil)

Bichimi: 60x84 $\frac{1}{16}$ “Times New Roman”
garniturada raqamli bosma usulida bosildi.
Shartli bosma tabog‘i 3. Adadi:100 nusxa.
“POLYGRAPH SUPER SERVICE” SHK bosmaxonasida chop etildi.
150100 Farg‘ona shahar, Aviasozlar ko‘chasi, 2-uy.